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The Journal of ELECTRICITY POWER and GAS

DEVOTED TO THE CONVERSION, TRANSMISSION and DISTRIBUTION OF ENERGY.

VOL. XIV.—No. 2 SAN FRANCISCO, CAL., FEBRUARY, 1904. YEARLY SUBSCRIPTION - $2.00 SINGLE COPIES - 25 CENTS

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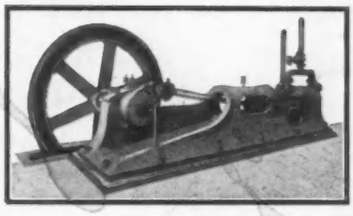

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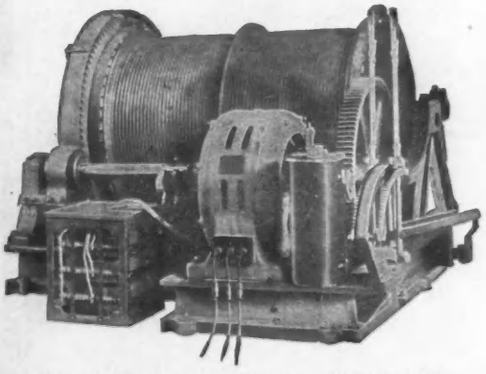

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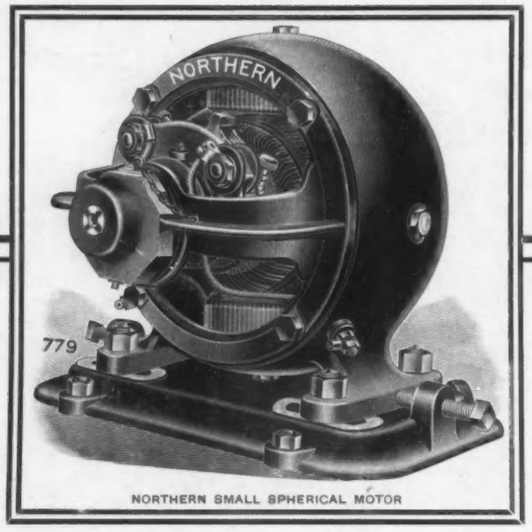

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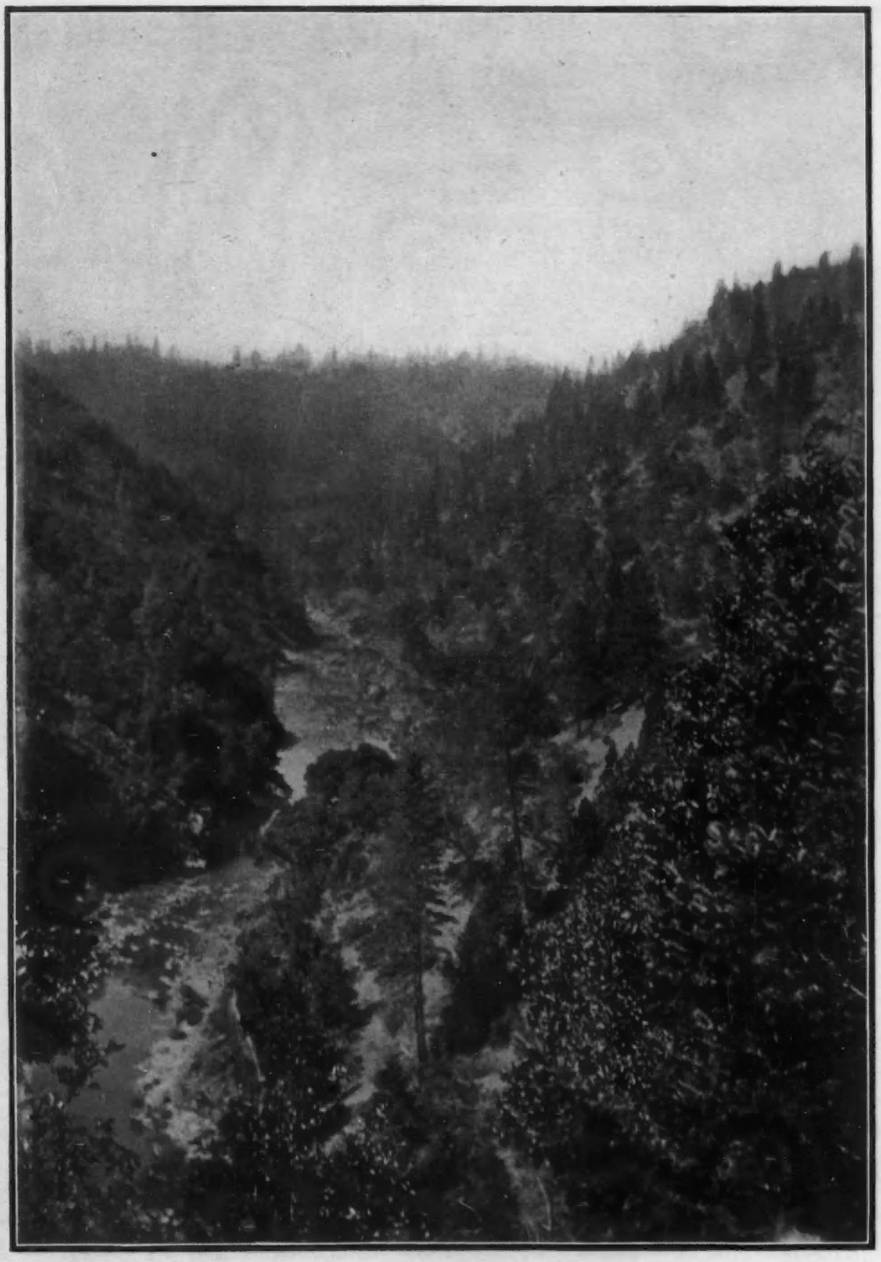
The Journal of Electricity, Power and Gas.

Devoted to the Conversion, Transmission and Distribution of Energy.

VOLUME XIV. SAN FRANCISCO, CAL., FEBRUARY, 1904. NUMBER 2

The American River Electric Company's Plant on the South Fork of the American River.

[Five years ago the construction of a transmission line of the magnitude of the American River Electric Company would have called forth columns of comment and description from every editorial writer on the Pacific Coast. Special reporters would have been assigned to obtain a good "write-up," with illustrations of the plant, and portraits of the capitalists and engineers interested in the work.

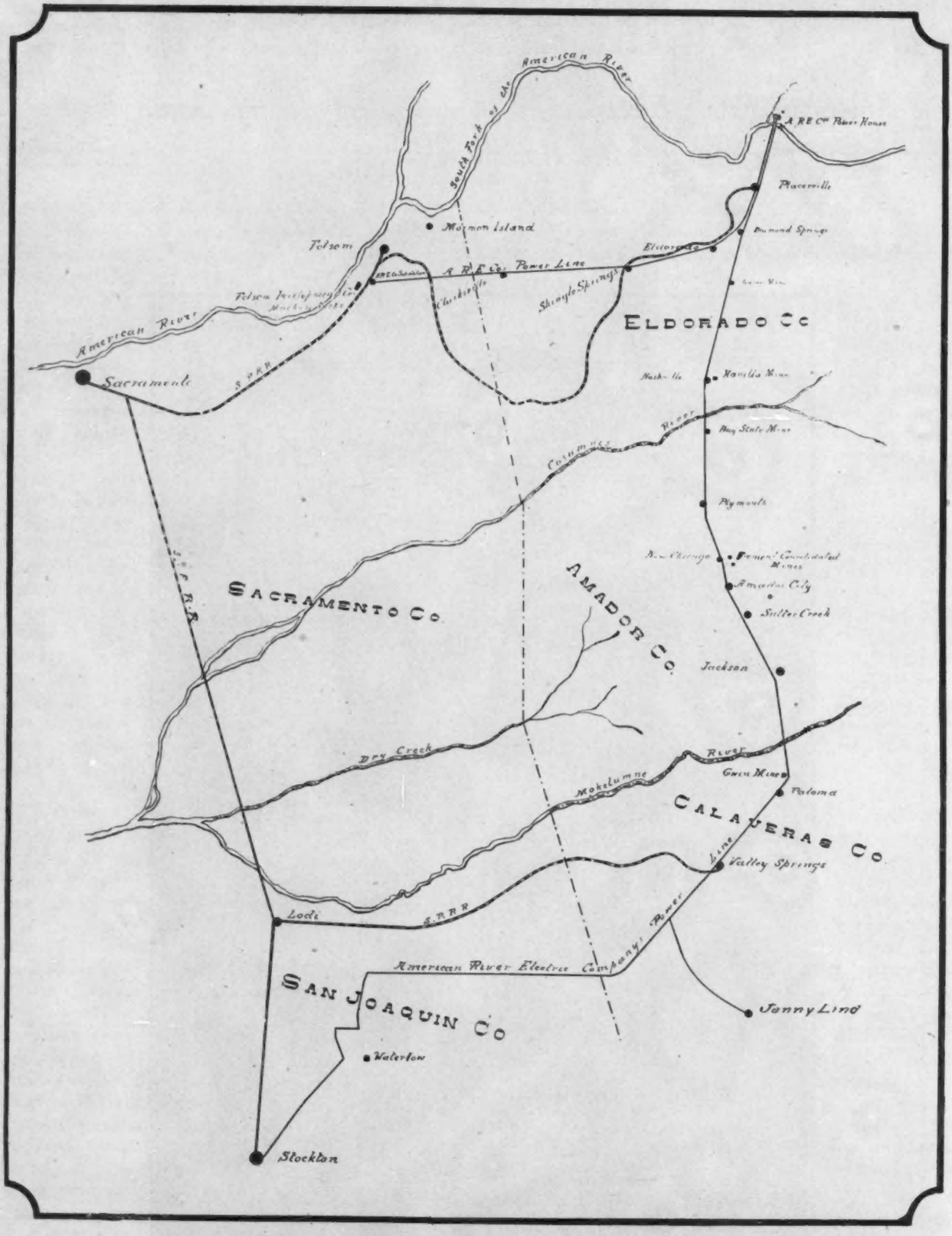


SCENE ON THE AMERICAN RIVER. SOURCE OF WATER SUPPLY OF THE AMERICAN RIVER ELECTRIC COMPANY

Whether it is that Californians are becoming used to the idea of long distance transmission, owing to the many magnificent plants already in operation, or whether the builders of the American River Company's plant were too modest to exploit their enterprise, or whether notices of electrical progress have become a drug in the columns of the daily press, the fact remains that a large plant has sprung up "almost in a night," in a thickly settled portion of central California, without its existence being heralded or even known through the usual mediums of current happenings.

A few local capitalists, through the enterprise of an engineer, had pointed out to them the possibilities of a rare location—they knew a good thing when they saw it, and without any "promoting" or seeking outside assistance banded together, subscribed the necessary capital and with characteristic zeal put through their project on what is record time, and are now enjoying the fruits of their sagacity and labor.

The work of construction was begun July 1, 1903, and the plant was in regular operation on December 31st of the same year, despite the fact that roads had to be built in a



MAP SHOWING POLE LINE OF THE AMERICAN RIVER ELECTRIC COMPANY'S SYSTEM

rough and mountainous country, bridges constructed and many difficulties in the way of engineering work encountered. Notwithstanding what may be termed its hasty building, the plant stands today as a model transmission line among the many of the Pacific Slope.—THE EDITOR.]

IN April, 1903, after all the preliminary data had been secured, the American River Electric Company was incorporated with the following board of directors: Mortimer Fleishhacker, Herbert Fleishhacker, Lieutenant-Governor Alden Anderson, W. E. Gerber, Frank Buck, Henry Kahn and W. A. Bell. The officers elected were Mortimer Fleishhacker president and Herbert Fleishhacker secretary. The plans laid out were for a 3000-kilowatt plant, with provisions for extensions covering a distributing pole line of 110 miles.

Contracts were let and active work inaugurated on July 1, 1903.

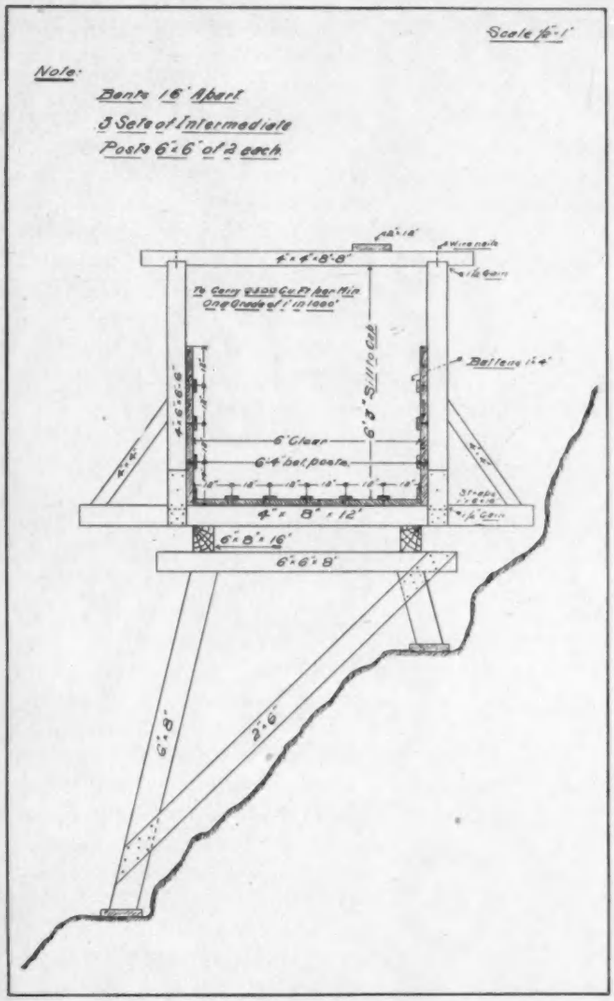
The power house is located on the South Fork of the American River, four miles north of Placerville, El Dorado County. From this point power is transmitted to Stockton, a distance of eighty miles, and also to Folsom, thirty miles distant, both of these points being served by separate lines direct from the power house.

The longer line passes through the towns of El Dorado, Plymouth, Amador City, Sutter Creek, Jackson, Valley Springs and into Stockton; the shorter branch through Diamond Springs and Shingle Springs before reaching Folsom.

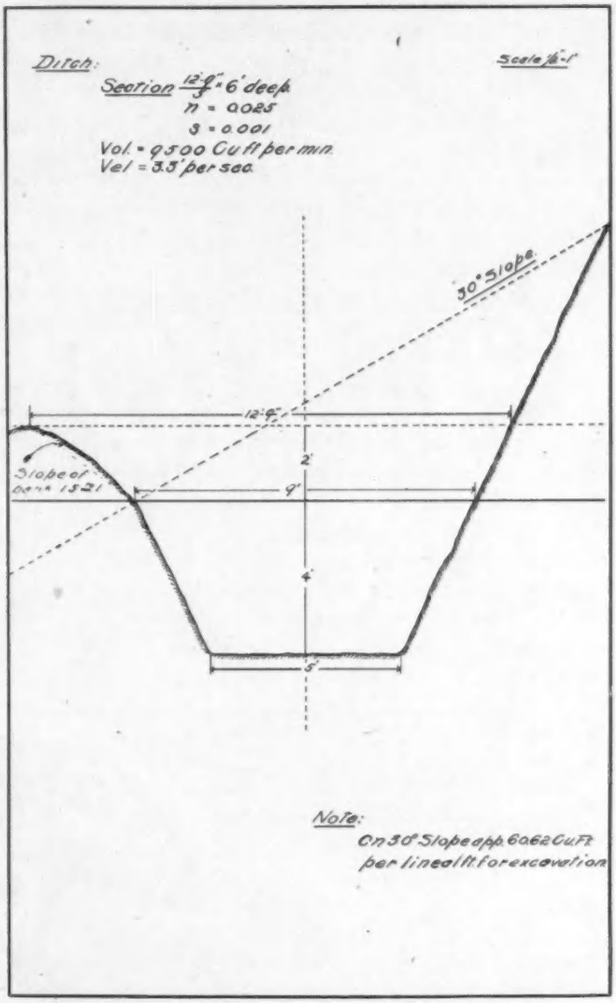
Placerville is fed by a separate 2200-volt circuit, direct from the generators, the other lines being built with the ultimate intention of operating at a potential of 60,000 volts.

The dam is situated approximately seven miles above the power house, and on account of the roughness of the country the first four and one-half miles leading from it is nearly all flume, broken occasionally with a short stretch of ditch. The remainder of the waterway is entirely good ditching.

The flume is six feet in width and at present is planked four feet on the sides, provision being made for increasing to six-foot sides when the growth of the plant warrants,



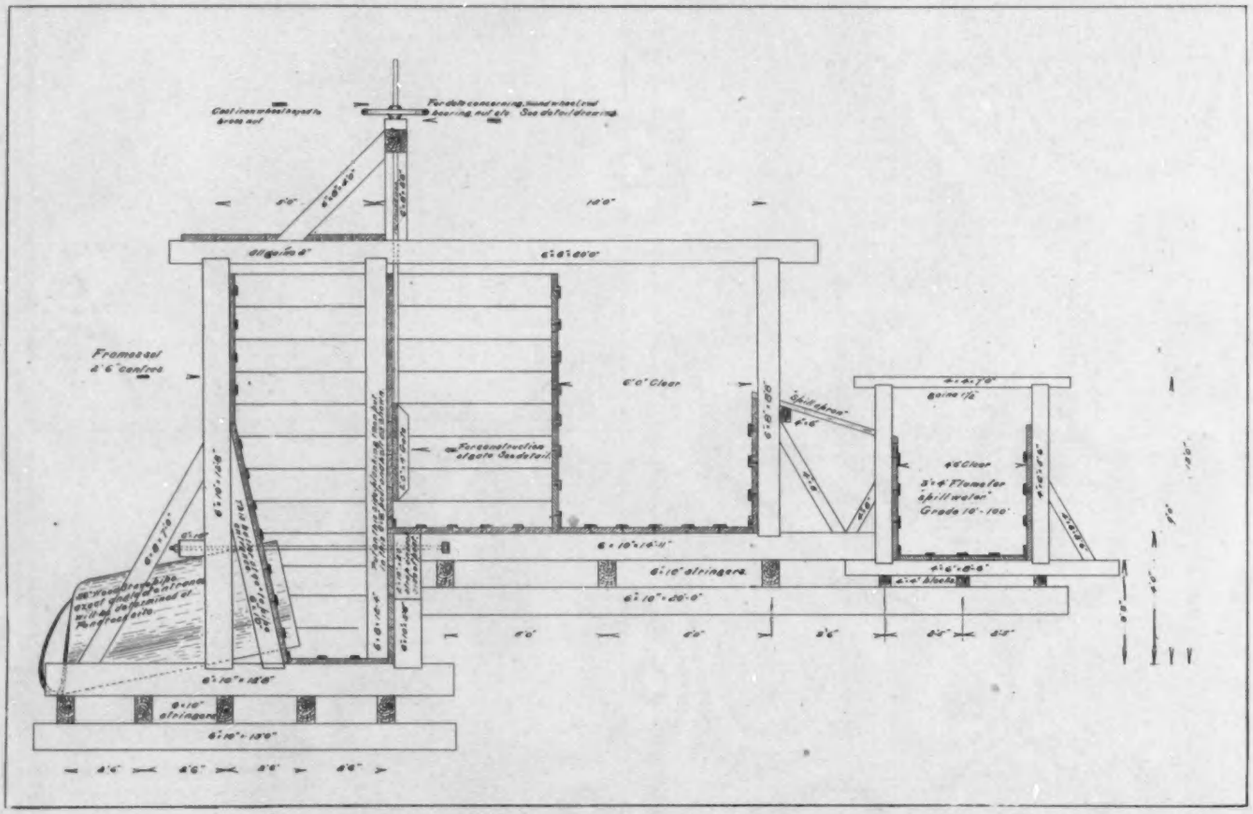
FLUME DETAIL OF THE AMERICAN RIVER ELECTRIC COMPANY'S SYSTEM



DITCH DETAIL OF THE AMERICAN RIVER ELECTRIC COMPANY'S SYSTEM

which will give the flume a capacity of about 9500 cubic feet per minute. The grade is one foot in a thousand, the flow of water being smooth and even, owing to the bottom and sides of the flume, as well as the battens, being surfaced lumber. The accompanying drawings of flume and ditch show the flume and ditch construction. From the fact that the waterway lies on the north bank of the river, exposed constantly to the sun, no danger of freezing in the winter months is anticipated. Spill gates are provided at intervals to turn the water out when needed.

Should it become necessary to make repairs or changes in the upper portion of the flume, water can be used from



SECTIONAL VIEW OF PENSTOCK OF THE AMERICAN RIVER ELECTRIC CAMPANY'S SYSTEM

two creeks flowing into the ditch some two miles from the power house, which in winter develop a sufficient volume to run the entire plant. In addition to the supply furnished from above the dam, and these small streams, storage reservoir sites have been secured in close proximity to the waterway capable of impounding a vast amount of water, so that the source of power may be always relied on.

The penstock is of timber construction, provided with sluicing gates and a spillway of sufficient capacity to take care of all the water in case of a shut-down.

Extending the whole length of the penstock is a double screen, made of half-inch, square-mesh, galvanized iron wire, which is stretched over small iron frames. These frames are adjusted in such a manner that any section may be conveniently moved and cleaned, and also that none of the pipes is dependent on any one portion of the screen for water, so that an insufficiency of water, through the choking of the screen, is an eliminated element.

While at present there are but two pipe lines leading from the penstock, provision has been made for the addition of another should it become desirable or necessary.

From specially constructed boxes attached to the penstock two pipe lines extend to the power house, each being thirty-six inches in diameter throughout. The upper 400 feet of these lines is of redwood stave, with a maximum head of 120 feet, the rest being of varying thicknesses of riveted sheet steel. The maximum static head from the penstock water level to the center of nozzles is 575 feet.

Each line branches at the bottom just outside the power house, forming a Y, the branches leading to the nozzles of two Pelton water wheels carried on the ends of the generator shaft.

The power house is constructed of concrete, with steel trusses and a slate roof, making it thoroughly fireproof, and incidentally providing a cool place during the hot summer months. Running the entire length of the building is a hand-operated, twenty-ton crane. Two Westinghouse three-phase, 1500-kilowatt, sixty-cycle, 2200-volt, engine-type generators furnish the power, the sub-base bearings and shafts forming a part of the water-wheel construction. The shaft is of forged nickel steel and has a

five-inch hole bored through the center from end to end. Each generator is driven by a double water-wheel unit, each unit being provided with a type "Q" Lombard governor for operating the two nozzles through a rock shaft.

The wheels are constructed of cast-steel runners fitted with cast-iron Pelton buckets, the maximum output of each double unit being 3000 horsepower. The wheels are equipped with combination deflecting and needle regulating nozzles of Pelton design and construction.

The two bearings of the generator shaft are of the ring-oiling, generator type, the shells carrying the oil and being provided with water-cooling compartments. Inside of the wheel housings the water for circulating is caught in a trough of sufficient elevation to flow through the compartments to keep the oil cool. Water is also led into the ends of the hollow shaft through a one-inch pipe, which discharges it at the bearing portions of the shaft.

In addition to the generating units above mentioned, there are two exciter sets, each consisting of a seventy-five-kilowatt, 125-volt, 750 revolutions per minute, Westinghouse, multi-polar, direct-current generator, driven by a twenty-eight-inch Pelton wheel, either set being of sufficient capacity to excite the main units. The water for the exciter wheels is taken from the main lines just outside of the building, the arrangement being such that each set may be driven from either pipe line. A type "F" Lombard governor is set between the exciter wheels, so situated as to control either unit.

The switchboard consists of seven panels of bevel-edged Vermont blue marble ninety inches high, mounted on an angle-iron framework. The panels are designated as follows: A, exciter; B and C, generator; D, blank; E and F, transformer, and G, Placerville circuit. On the exciter panel are mounted one 150-volt, direct-current, type "D" voltmeter, two 1000-ampere, direct-current, type "D" ammeters, one five-ampere, alternating-current, type "F" ammeter (the last named being used in connection with a water signal for the penstock), two 800-ampere, three-pole, double-throw, quick-break switches, two field rheostats, pilot lamps and plugs.

Panels B and C, for controlling the two 1500-kilowatt, 2200-volt, three-phase machines, have three indicating recording ammeters. one indicating Bristol recording voltmeter, one frequency indicator one power-factor indicator, two 600-ampere, single-pole, oil-break switches, one double-throw, two-pole, field switch, with resistance, one rheostat mounting, pilot and synchronizing lamps and voltmeter plugs.

Panel D will be used for controlling the third main unit when installed, and will resemble in all respects panels B and C. On each transformer panel is mounted one 800-ampere, alternating-current-type ammeter, two 600-ampere, 2200-volt, three-pole, single-throw, type "B," interlocking circuit breakers.

On panel G is one triple-pole, double-throw oil switch, one Bristol recording voltmeter and three Bristol recording ammeters and fuses.

One interesting feature of the switchboard is a swinging arm, on which is mounted a synchroscope and indicating voltmeter, so connected that by means of plugs they can be thrown on any of the circuits desired.

Another feature is an electric attachment to control the governors of the main units, allowing the attendant to manipulate them from the switchboard.

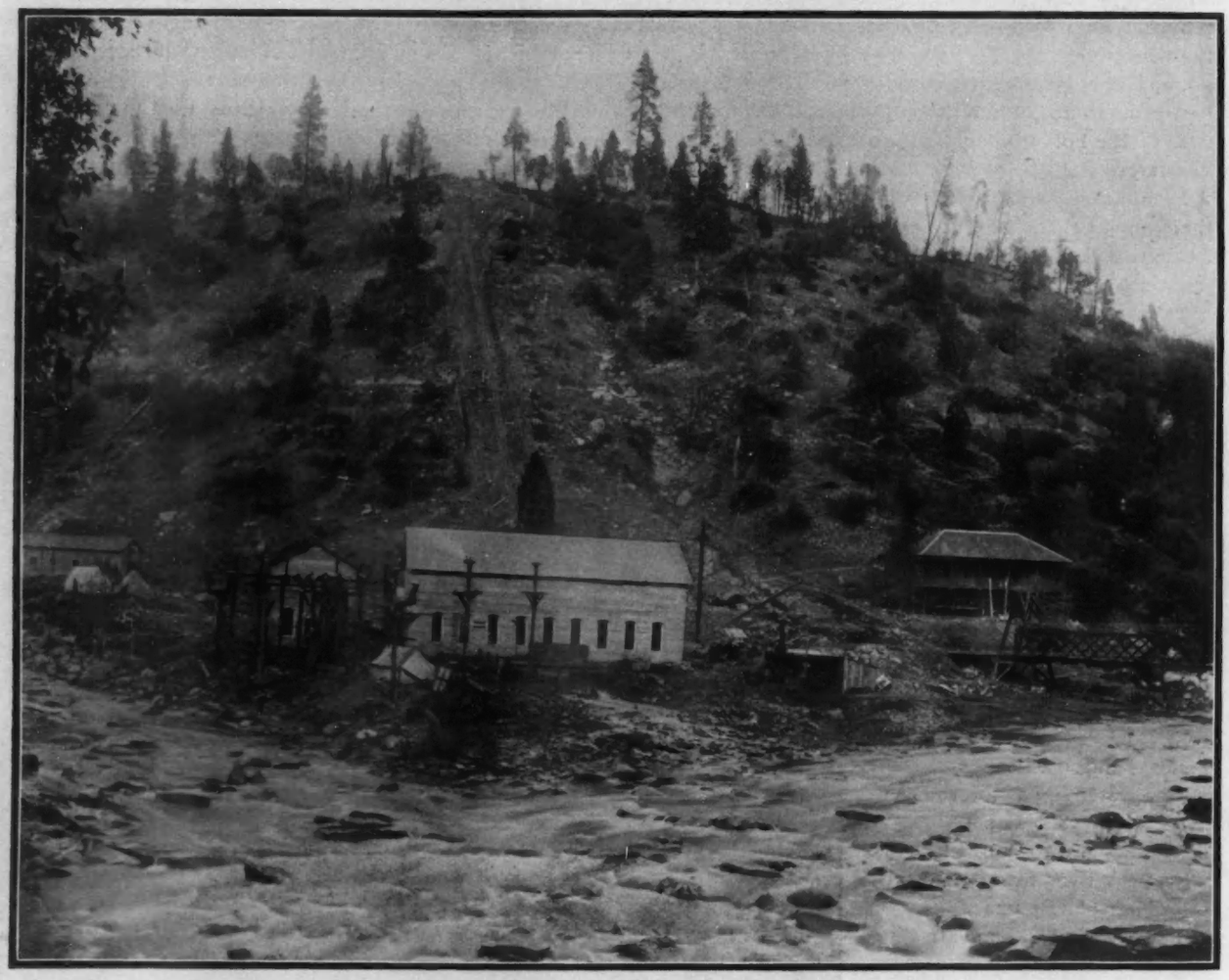
The ammeter on panel A, which is used in connection with the water signal, is in series with a solenoid at the penstock, on a 110-volt, alternating-current circuit. An iron core controlled by a ball float in the penstock moves in and out of the solenoid, thus changing the amount of current in circuit, which is shown on the ammeter. The solenoid is wound so that the current change is almost a straight line, enabling the attendant to determine the exact position of the water in the penstock.

All generator leads are carried to the switchboard, under the floor of the power house, in six-inch glazed sewer tiling, and the wires for lighting purposes in flexible iron conduits imbedded in the walls. The lead wires are rubber-covered, double-braid cable of 250,000 circular mils and run in pairs from the generators to the switchboard.

In a separate building, the materials of which are identical in construction with the power house and twenty-five feet distant therefrom, are located the step-up transformers. These are seven in number, six being in active service, the other held as a spare.

AMERICAN RIVER ELECTRIC COMPANY'S POWER HOUSE IN COURSE OF CONSTRUCTION

The transformers are of 625 kilowatts capacity each, oil insulated, water cooled, and designed to be connected for "star" in line voltages of 60,000, 50,000, 40,000 or 30,000 volts, and in delta for the generator side. The regulation at 100 per cent. power factor is 1.75 per cent., and they will operate continually at full load with a rise in temperature not exceeding 40 degrees above the surrounding atmosphere. The transformers are mounted separately on steel trucks with cast-iron wheels, allowing them to be readily moved about. Each requires two and one-half gallons of water per minute for cooling purposes.



POWER HOUSE OF THE AMERICAN RIVER ELECTRIC COMPANY

Every precaution has been taken in the transformer house against damage resulting from fire. In addition to a three-inch wrought-iron pipe leading from each transformer case to the outside of the building, allowing for the running off of the oil, an ingenious automatic device has been attached to the outlet pipe which eliminates attention from any other source. It consists of a small drum ten inches in diameter, with a three-inch face, fastened to the valve stem, around which is wound twelve turns of flexible wire cord. This cord on leaving the drum passes over a system of small iron pulleys to the outside of the building, and has attached to the end of it an iron weight, held up so as to have a drop of two feet by a hemp cord, which passes into the building and just over the top of the transformer case. In the event of fire the cord is burned through, releasing the weight, which in descending will unwind the drum, thereby opening the valve full, allowing the oil to run off through the pipe to the outside.

The low-tension leads are carried underground in six-inch glazed sewer tiles, while the six-inch high-tension wires leave through twenty-four-inch conduits of the same material set in the end wall of the building.

Inside, the high-tension leads are carried on fourteen-inch Locke insulators, supported on six-by-eight-inch beams running across the building above the transformers, connections being made with transformer leads by taps.

Outside the building are located the high-tension switches and lightning arresters, the latter being of the horn type, and mounted so that they may be easily adjusted for any desired voltage by loosening two nuts and moving the horn support on the grounded side. The

resistance used between the ground branch horn and the ground is a glazed earthern jar filled with water and mounted on an insulated platform.

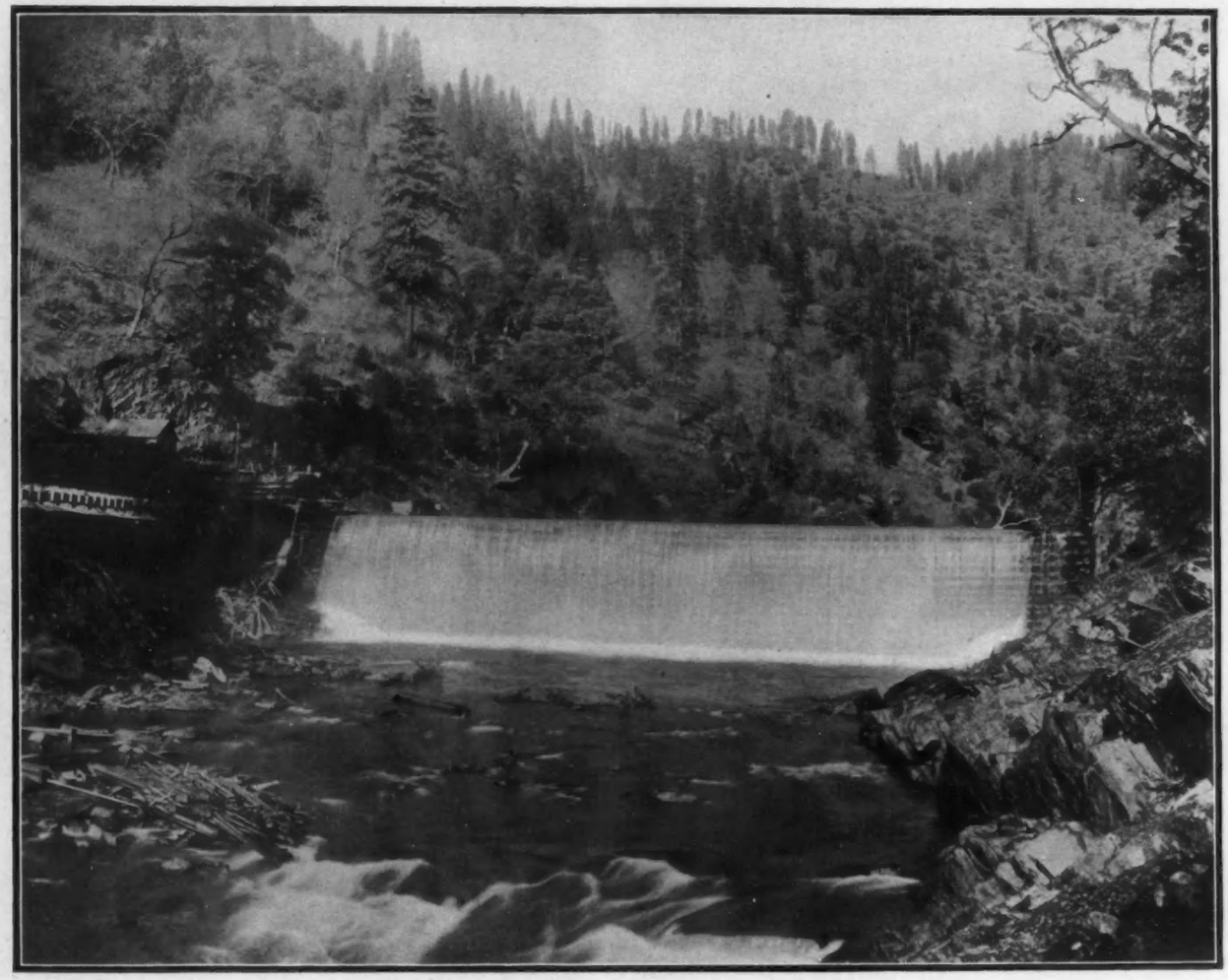
Inside the lightning arresters choke coils are inserted between the line and the transformers, made up of twenty-four turns of No. 2 B. & S. gauge, hard-drawn copper wire, the coils being eight inches in diameter and supported by a length of glazed sewer tile resting on two Locke insulators. The coils are slipped over the pipe, then pulled apart and the ends so fastened that there is about one-quarter-inch air space between each turn of coil.

The high-tension switches are of a fused type. The two knife edges are connected by means of a glass rod, and the two points fused, the fuse being held beneath a winged net.

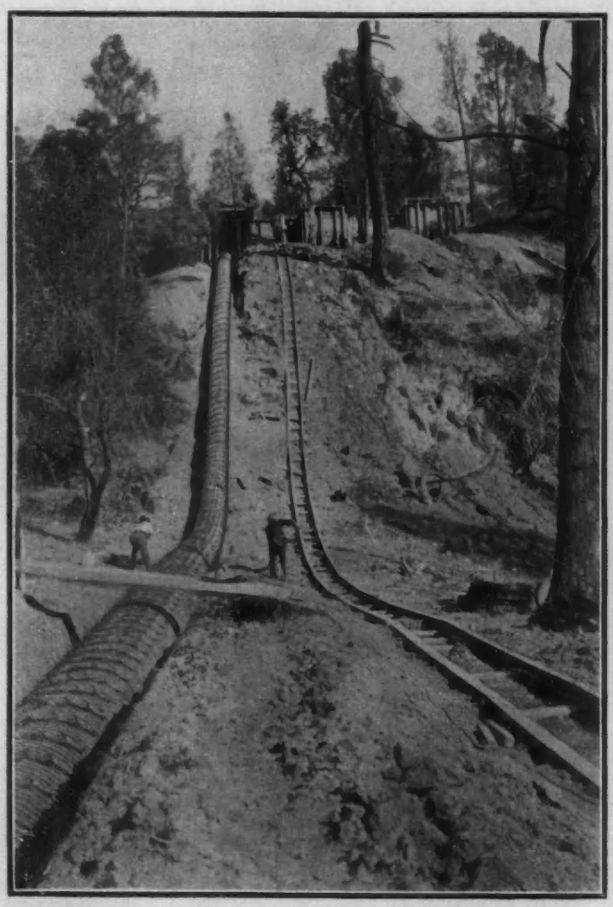
The parts of the switch are few and simple, the arrangement of which may readily be seen from the accompanying diagram. The triangular-shaped part which carries the brass clips is fastened to a standard fourteen-inch Locke insulator by means of a screw and stud securing it to a clamp surrounding the neck of the insulator. The leads are sweated into the ends of the brass runways at the bottom. When the switch is pulled, or the fuse blows, the magnetic field is below the arc, thus not interfering with the tendency of the arc to travel upwards.

Great care has been taken to protect the attendant while operating the switch. An insulated handle is provided six feet in length, on the upper end of which is a brass socket, which makes connection with an attachment on the glass rod supporting the knife edges by means of a bayonet joint. Between the socket and the handle-grasp is four and one-half feet of one-and-one half-inch round maple, treated with a weather-proof varnish, the handle-grasp being made up of a piece of heavy glass tubing, one and one-half inches outside diameter, slipped over a projection of the wooden portion and firmly glued. The glass is covered by a section of the best quality rubber hose, the ends being securely sealed with an insulating compound.

To guard against the attendant coming in contact with the insulated portion of the handle, a shield is provided at the upper end of the handle-grasp. This consists of a circular piece of plate glass four and one-quarter inches



DAM OF THE AMERICAN RIVER ELECTRIC COMPANY

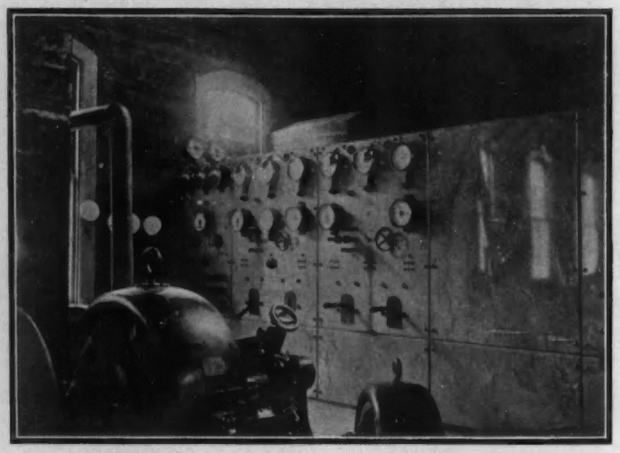


PENSTOCK AND PIPE LINE OF THE AMERICAN RIVER ELECTRIC COMPANY

in diameter, with a one-and-three-eighths-inch hole drilled in the center, which is slipped over the pole, and protected from breakage by a fiber washer of rather larger dimensions inserted behind it, the glass being next the hand. As a further precaution the upper portion of the handle is grounded by means of a brass chain. The switch is operated by the attendant from a platform built upon six fourteen-inch Locke insulators, affording further immunity from accident.

As usual in most of California's hydraulic transmission plants, it was necessary to construct a road to the power house of the American River Company, but in this case a bridge was required to span one of the streams encountered. That the bridge forms not only a useful, but an ornamental part of the road as well, can be seen from the engraving.

The bridge is of the suspension type, supported by two plow-steel cables two and one-half inches in diameter.



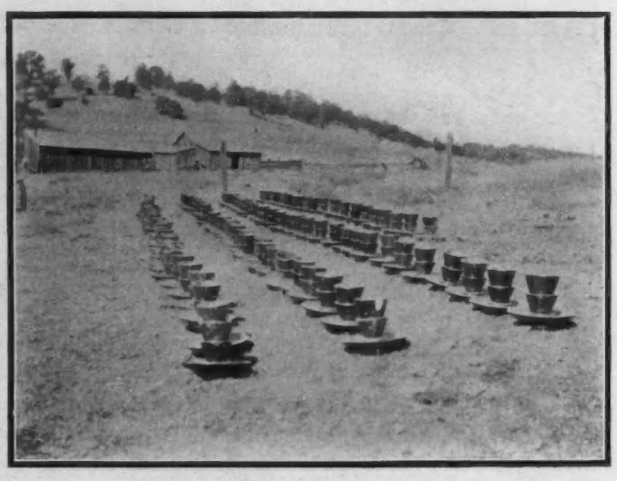
THE SWITCHBOARD AT THE AMERICAN RIVER ELECTRIC COMPANY'S POWER HOUSE

From these is hung the floor, on either side of which is a stiffening truss with eight-by-eight-foot panels. The span from bank to bank is 232 feet.

The transmission line is double, each one carrying three-phase circuits of No. 1 B. & S. gauge seven-strand bare aluminum wire, weighing approximately 401 pounds per mile, the lines being twenty-five-foot centers. The poles are well seasoned round cedar, set 180 feet apart, the butts for protection being throughly treated to a coating of Carbolineum Avenarius.

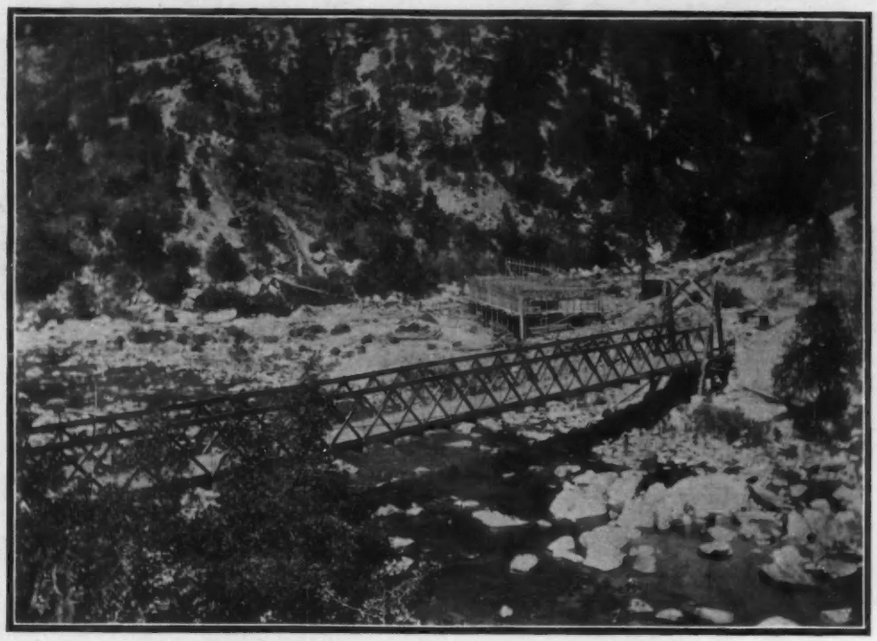
The dimensions of the cross-arms are four and three-quarter by five and three-quarter inches by seven feet. Two wires are carried on fourteen-inch Locke insulators attached to these, with pin holes six-foot centers. The

HOW THE MACHINERY WAS TRANSPORTED



A FIELD OF LOCKE INSULATORS

third wire is fastened to the tops of the poles. Pins for cross-arms are seventeen and one-half inches in length and for the tops of the poles nineteen and one-half inches. To keep the poles from splitting the tops are wound with eight turns of No. 10 galvanized iron wire. Each pin is protected from leakage discharge by the entire length of its shaft being wrapped in sheet zinc, the extra cost for which is less than 3 cents per pin.

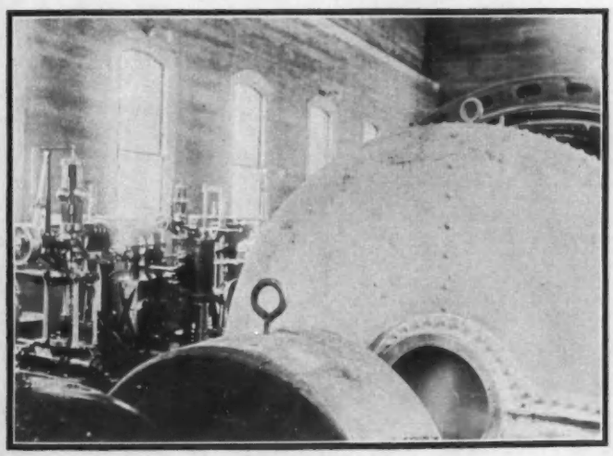


BRIDGE 232-FOOT SPAN, AMERICAN RIVER ELECTRIC COMPANY

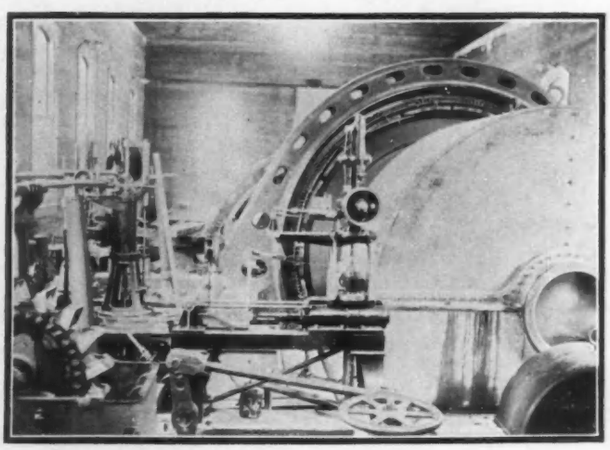
The Placerville wire is carried from the power house to that point on cross-beams six by eight inches, spanning opposite poles, as is also the telephone line. From Placerville to other points the telephone wire runs on separate cross-arms set below the transmission lines.

Two substantial substations have been erected, one at Folsom, constructed of corrugated iron and covered with "P. & B." roofing, the other of brick at Stockton. Both of these substations are equipped with high-tension switches and lightning arresters with choke coils, similar in all respects to those installed outside the main power house. Aside from the revenue derived from commercial sources, the company at present is enjoying very substantial returns from the power supplied numerous mines situated adjacent to the pole lines, and looks forward to a further income from furnishing power for pumping purposes to develop the rich low lands tributary to it. Abundance of water can be had in these localities at a depth of twenty feet and, with cheap power at hand, the agricultural interests of this section of the country will receive a fresh impetus.

The design and construction of this plant, from beginning to completion, was the work of A. M. Hunt, of the Engineering Offices at San Francisco, and it was due to his skill, knowledge, energy and foresight that the many engineering difficulties were overcome and the plant completed and put in operation in such a marvelously quick time. Mr. Hunt achieved a national reputation when he installed the plant of the Independent Electric Light and Power Company, this plant being recognized as the best and most up-to-date of its kind in the United States. The absorption of this company by the San Francisco Gas and Electric Company and the resignation of Mr. Hunt as general manager, leaves him free to devote his time to the development of other work. In building the American River plant he was ably assisted by B. C. Condit, superintendent of the company.



PELTON WATER WHEEL IN AMERICAN RIVER ELECTRIC COMPANY'S POWER HOUSE



ONE OF THE 1500-KILOWATT GENERATORS

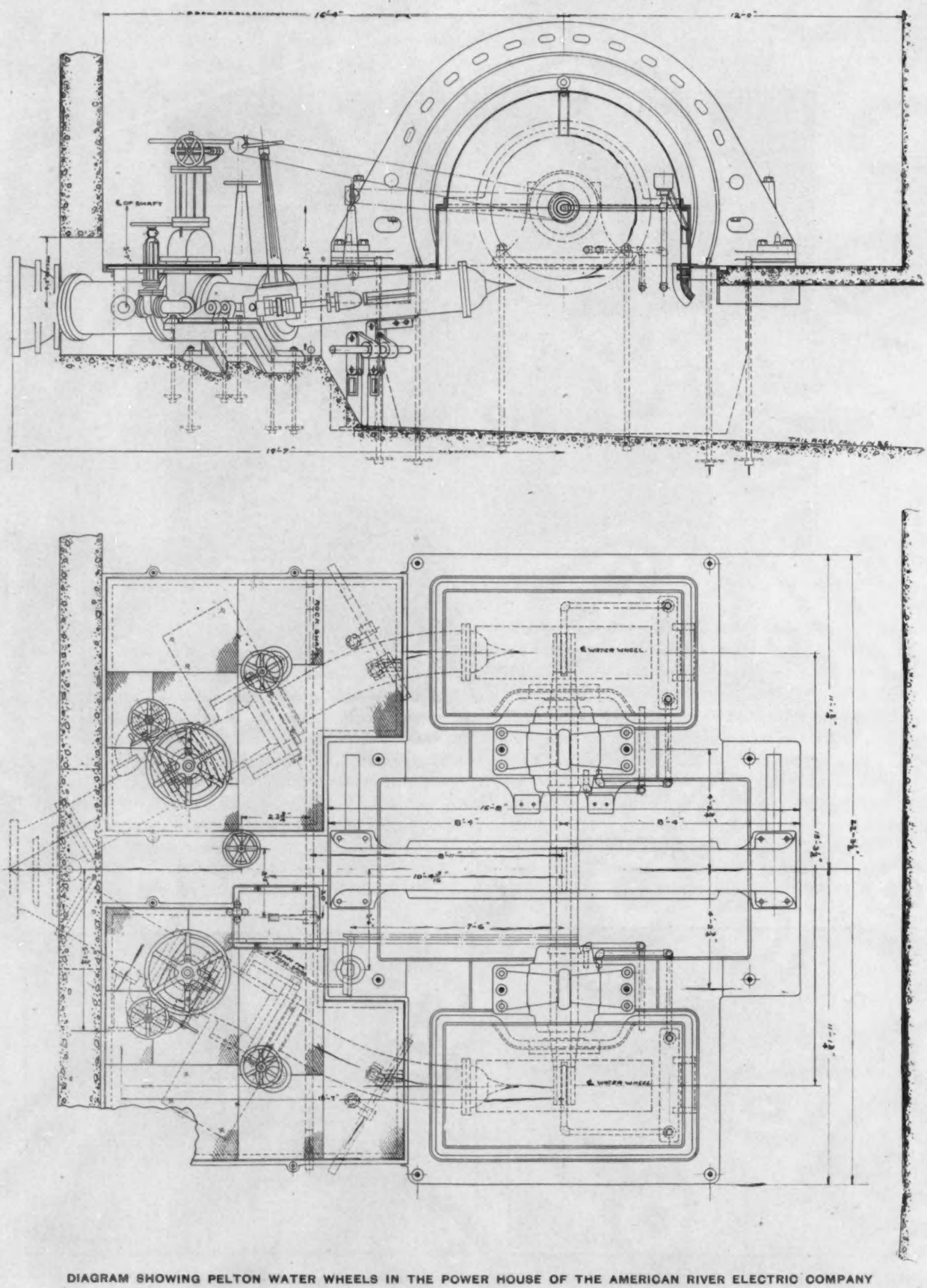
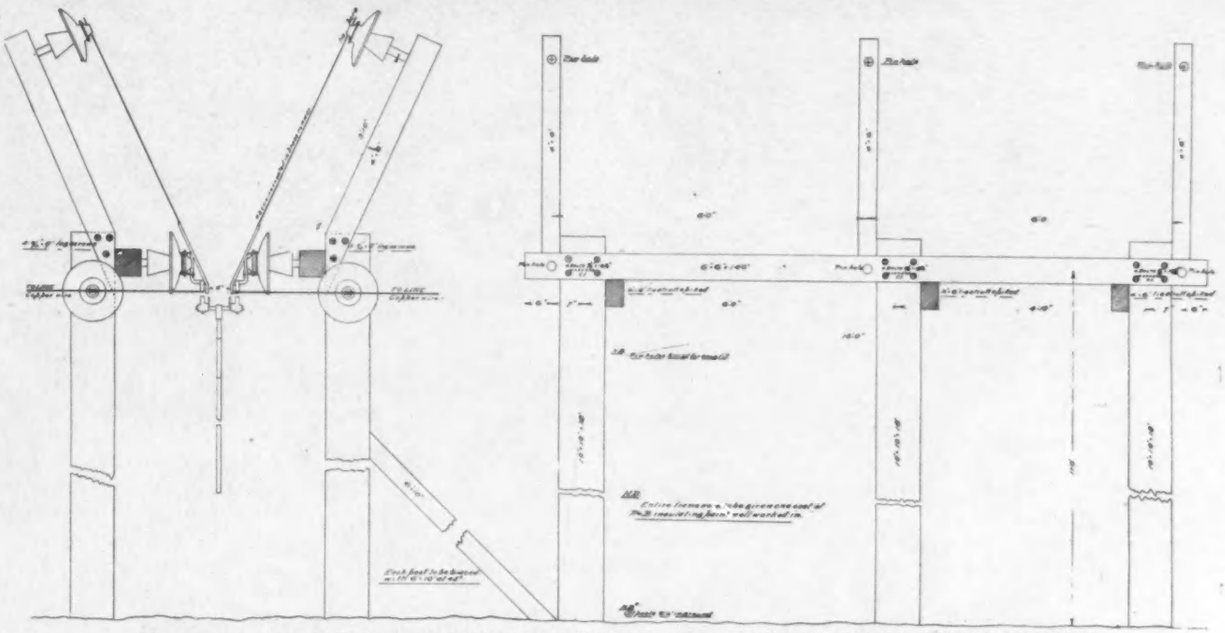
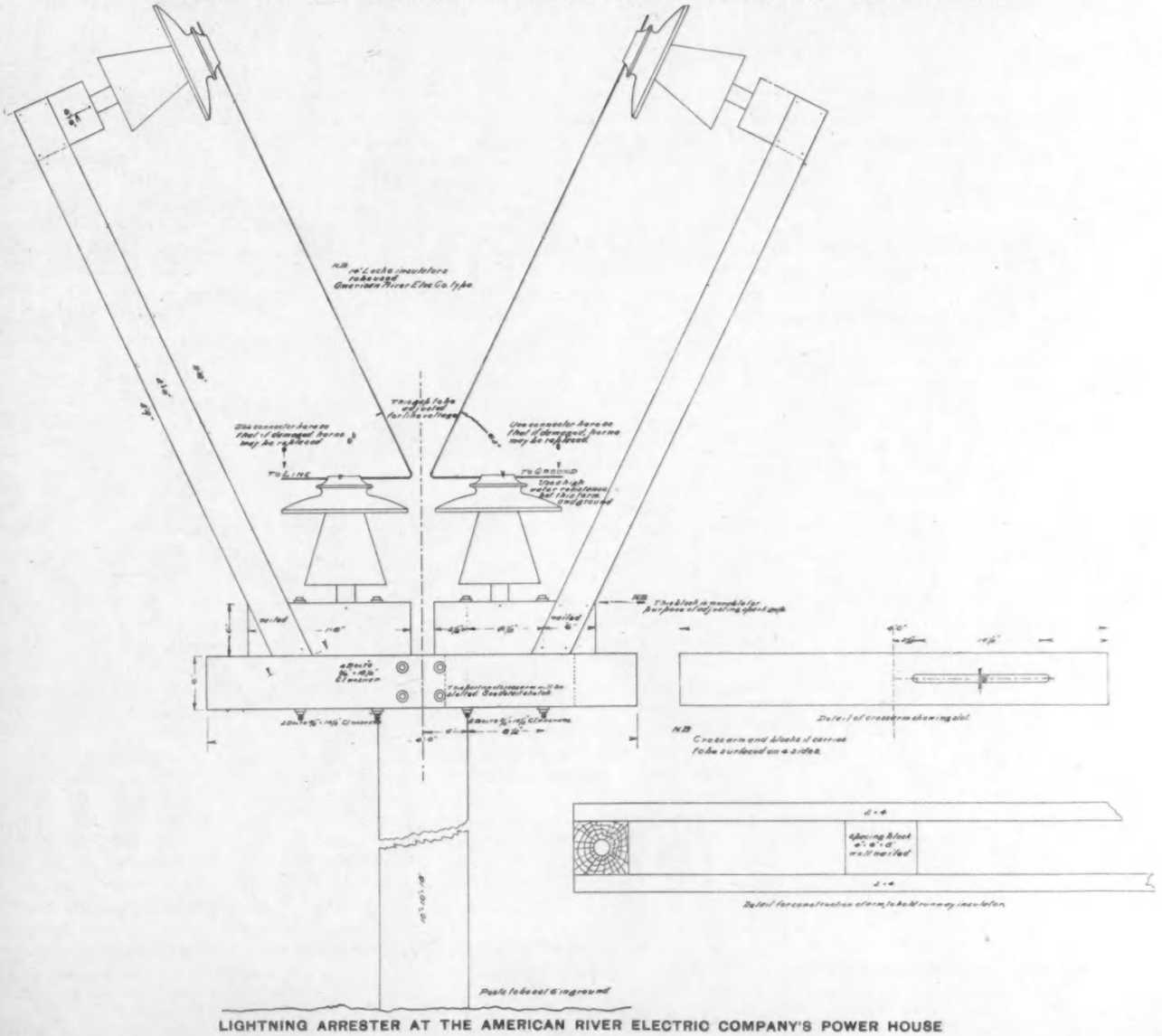


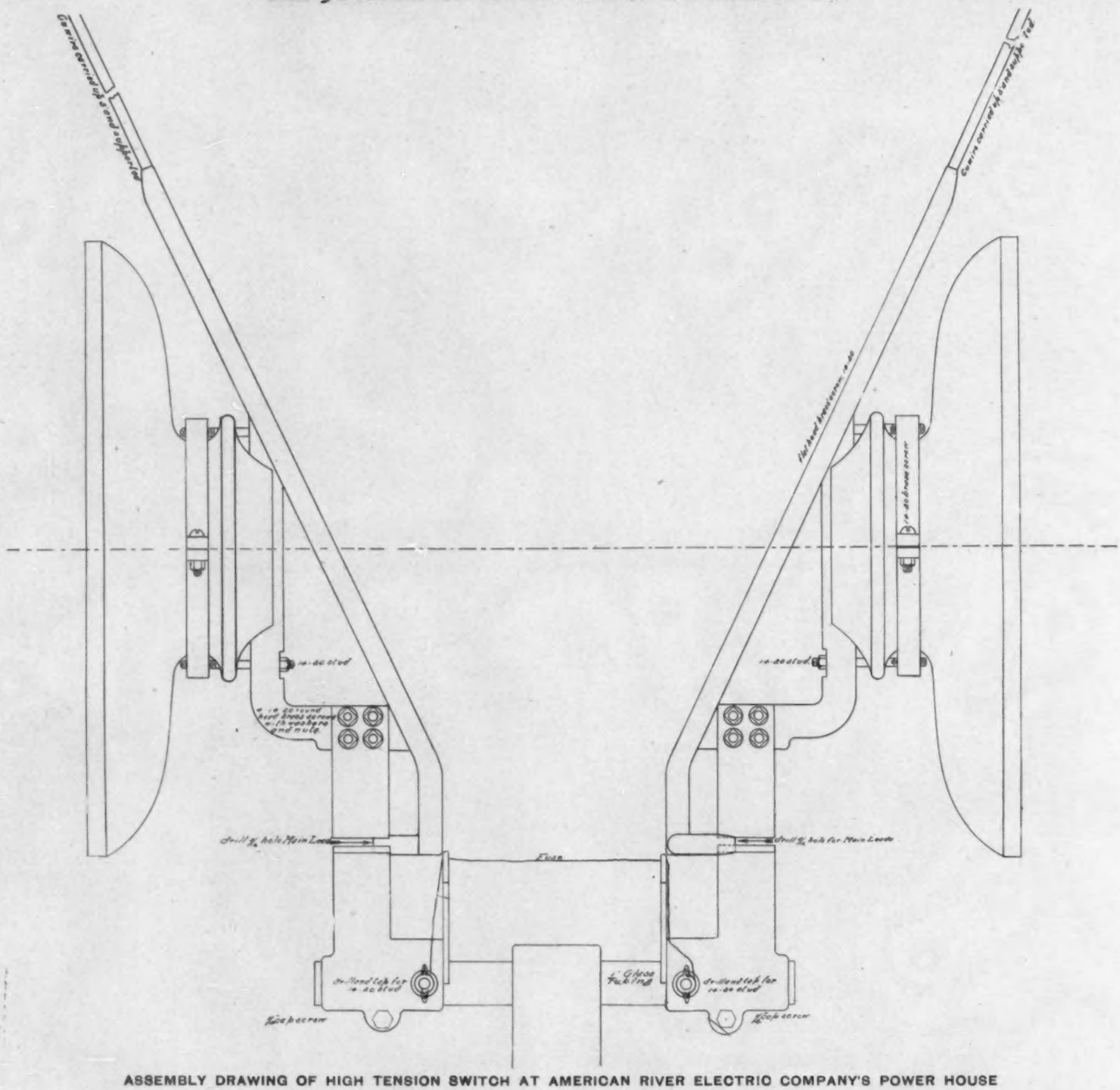
DIAGRAM SHOWING PELTON WATER WHEELS IN THE POWER HOUSE OF THE AMERICAN RIVER ELECTRIC COMPANY



FRAMEWORK AND ASSEMBLY OF SWITCH AT POWER HOUSE OF AMERICAN RIVER ELECTRIC COMPANY



LIGHTNING ARRESTER AT THE AMERICAN RIVER ELECTRIC COMPANY'S POWER HOUSE



ASSEMBLY DRAWING OF HIGH TENSION SWITCH AT AMERICAN RIVER ELECTRIC COMPANY'S POWER HOUSE

TECHNICAL DATA AMERICAN RIVER ELECTRIC COMPANY'S SYSTEM.

HYDRAULIC WORKS.

Dam—
- Timber crib, rock filled.
- Width on crest, 19 feet.
- Width on bottom, 50 feet.
- Height, 30 feet.
- Length, 210 feet.

Flume—
- Width, 6 feet.
- Depth, planked, 4 feet at present; provision made for 6-foot sides.
- Grade, 1 foot in 1000.
- Capacity, 9500 cubic feet per minute.

Ditch—
- Section, $\frac{13 \text{ feet}}{5 \text{ feet}}$ x 6 feet deep.
- Capacity, 9500 cubic feet per minute.
- Grade, 1 foot in a 1000.

Penstock—
- Construction, timber.
- Width, 11 feet.
- Depth, 6 feet.
- Length, 60 feet.

Screen—
- Double, ½-inch, square-mesh, galvanized iron wire, No. 6, stretched on angle-iron frames, 3x7 feet.
- Length (total), 60 feet.

Pipe Boxes—
- Number, 3.
- Width, 5 feet.
- Depth, 12 feet.
- Length, 10 feet.

Gates—
- Two gates each box; size, 2 feet 3 inches by 3 feet 6 inches.
- One gate at end of penstock for flushing; size, 2 feet 3 inches by 3 feet 6 inches.

PIPE LINES.

Number—
- Two; provision for third.

Material—
- Redwood stave for 400 feet; rest riveted sheet steel.

Diameter—
- 36 inches.

Maximum Static Head—
- Wood stave, 120 feet.
- Center of nozzles, 575 feet.

Length of Steel Pipe, 2d thicknesses—
- 400 feet, 36 inches diameter, No. 10 U. S. gauge.

150 feet, 36 inches diameter, 3-16-inch thick.
150 feet, 36 inches diameter, ¼-inch thick.
150 feet, 36 inches diameter, 5-16-inch thick.
364 feet, 36 inches diameter, 7-16-inch thick.

PELTON WHEELS.

Main Units—
Two double-wheel units.
Effective head, 575 feet.
Revolutions per minute, 300.
Runners, cast steel.
Buckets, cast iron.
Horsepower, 3000 maximum.

Exciter Units—
Number, 2.
Diameter. 28 inches.
Buckets, bronze.
Horsepower, 100 each.

Governor—
Main units, 2-type "Q" Lombard.
Exciter, 1-type "F" Lombard.

Nozzles—
Main units, combination deflecting and needle regulating.
Diameter, 7 inches.
Exciter units, needle regulating.

ELECTRICAL EQUIPMENT.

Generators—
Main units, two 1500-kilowatt, 3-phase, alternating-current, rotating field tvpe.
Voltage, 2200.
Alternations, 7200 per minute.
Revolutions per minute, 300.
Exciter units, two 75-kilowatt, compound wound, multi-polar, direct-current generators.
Voltage, 125 volts.
Revolutions per minute, 750.

TRANSFORMERS.

Power House—
Number, 7.
Capacity, 625 kilowatts each.
Insulation, oil water-cooled.
Voltages, 30,000, 40,000, 50,000 or 60,000 volts; 2200 volts low-tension side.

Transmission—
Poles, lines double.
Wire, No. 1 B. & S. gauge, 7-strand, bare aluminum wire.
Weight, 401 pounds per mile.
Tie wires, soft, solid aluminum wire.
Poles, seasoned round cedar.
Height 35–65 feet.
Pins, eucalyptus.
Length, 17½–19½ inches.
Insulators, Locke No. 329, 14-inch.
Cross-arms, Oregon pine, size, 4¾ by 5¾ inches by 7 feet.

INTERURBAN ELECTRIC TRACTION SYSTEMS—ALTERNATING CURRENT VS. DIRECT CURRENT.*

BY P. M. LINCOLN

PRACTICALLY all the traction work in America has been done by direct current. The alternating-current traction system, although it has received considerable attention from American engineers, has not until recently been favorably considered by them. In Europe, on the other hand, the alternating-current traction problem has received a large amount of attention. The polyphase induction motor has been developed by European engineers for traction purposes, and a number of installations have been made in Europe with apparatus of this character. American engineers have consistently refused to adopt the polyphase induction motor for traction purposes, on the ground that it is not suitable for that purpose. The principal reasons for this stand are two in number, first, that the polyphase induction motor is inherently a constant speed motor, and, therefore, not adapted to traction purposes, and the second reason against the use of polyphase induction motors for traction purposes is the necessity for providing at least two overhead conductors.

The principal advantages of the alternating-current electric traction over the direct current are as follows:

1. Limits to trolley voltage are removed.
2. Avoidance of rheostatic losses.
3. The necessity for rotary converter substations abolished.
4. Manual attendance at the substations done away with.
5. Danger of electrolysis by return current avoided.

To take up these points more in detail:

1. The greatest item of cost in the electrical equipment of interurban traction systems, as they exist today, is that of secondary distribution. This item of cost usually carries somewhere between 25 per cent. and 50 per cent. of the total for electrical equipment, and is usually much nearer the latter figure than the former. Six hundred volts at the motor in a direct current traction system is practically the limit at which present designers and manufacturers are willing to guarantee their operation except in some special cases. This necessarily limits the voltage fed into the secondary distribution system to, say, 700 as a maximum. The consequence of this comparatively low voltage is naturally a high cost for conductors of the secondary distribution. The alternating current system, providing, as it does, the possibility of greatly increasing the voltage of the distributing system, thus cuts down largely the cost of the latter.

Another point which militates against the use of direct current is the fact that when large units are used it is difficult to collect the large amount of current for their operation. For this reason, as well as an advantage in cost, trolley construction has been largely replaced by the third rail for interurban work. By raising the voltage of the secondary system the current taken by a locomotive may be reduced, and consequently the difficulty with collecting devices may be made to disappear.

2. In the direct current system the voltage at the car is practically constant, and while the counter electromotive force of the motors is building up, the excessive voltage must be taken up by resistance. At the start, therefore, a comparatively large rheostatic loss occurs. With the alternating current system, on the other hand, the voltage at the car may be controlled by suitable means and the rheostatic loss thus avoided. When stops are few, and, consequently, runs are long, the rheostatic loss in the direct current system is a small proportion of the total, and, therefore, under these conditions this advantage of the alternating current system is not so greatly marked. With short runs, on the other hand, and consequently frequent starts, the rheostatic loss with the direct current system amounts to a considerably greater proportion of the total loss, and the alternating current system, therefore, can have the greater advantage.

Figures 1 and 2 show kilowatt curves for a car equipped in one case with direct current motors and in the other with alternating current motors. Were it not for the saving of rheostatic loss, one would expect that the alternating current equipment, being 18 per cent. heavier, would take 18 per cent. more power.

The actual difference in the areas under the curves, however, shows about 10 per cent. more power in the alternating current than the direct current on account of avoiding rheostatic loss in the alternating current equipment. If the run were for about one mile instead of two miles the consumption of power would be about equal, and for runs of less than one mile the alternating current power consumption would be less.

3. In substation equipment by far the largest item of cost is the rotary converters. In the alternating current equipment the rotary converter has no place, thus avoiding not only a large item of cost but also one of the largest items of the loss of power.

4. The direct current rotary being a piece of revolving machinery, of course, requires manual attendance at the various substations. Alternating current substations consist of static transformers only, and, therefore, require attendance only for the purpose of operating the switches.

5. Electrolysis of parallel conducting systems is generally recognized as one of the most serious dangers in connection with

*Abstract of a paper read before the electrical section of the Canadian Engineers' Society, Montreal, November 19, 1903.

present direct current trolley systems, and the fact that an alternating current system avoids this danger entirely need only be mentioned in order to be recognized as a marked advantage.

The disadvantages which necessarily accompany the use of the alternating current traction system are as follows:

1. Additional weight.
2. Difficulty of operating on existing lines.
3. Increased rail loss.
4. The fact that an active electromotive force exists between field turns.
5. Possible interference with telephones.

1. An alternating current motor of a given capacity is necessarily somewhat heavier and somewhat more expensive than a direct current motor for the same capacity. In order to make use of the advantages of high trolley voltage the alternating current equipment should preferably be provided with a step-down transformer on the car. Also, in order to obtain the advantages of avoiding the rheostatic losses some provision must be made for controlling the voltage on the car. The transformer, the voltage control apparatus, and the greater weight of motors make the alternating current equipment necesarily heavier than the direct current. Although this difference need not, and in many cases will not, be as great as the example cited later in this paper (18 per cent.), still a difference in weight will always exist detrimental to the alternating current equipment.

Practically all interurban roads run in and through cities on existing tracks, and, therefore, must use the existing sources of direct current power. In order to meet this condition the equipment for an alternating current interurban road must be so arranged as to operate on alternating current outside the city and on direct current inside. Although this is entirely possible, it must necessarily prove to be a matter of considerable complication. It means, in the first place, the use of motors which can be operated from both direct current and alternating current. This is entirely possible with the series alternating current motor.

3. Experiments have shown that with alternating current from 2000 alternations to 3000 alternations the actual loss which takes place with a given current through the iron rails is from three to five times that which the same direct current would give. The higher ratio of loss holds for the higher frequencies. At first thought this seems to be an important objection to the alternating current system. But when it is considered that in order to utilize the main benefit of the alternating current a higher trolley voltage is used, and, therefore, smaller currents in the return conductor, the element of rail loss in an alternating current proposition may be made even a smaller proportion of the total than in the direct current, in spite of this apparently large handicap.

The electromotive force between the field turns of a direct current motor is due simply to ohmic resistance, and a short circuit between turns simply throws out of action the turns so short circuited, and if not too severe, does not interfere seriously with the motor's operation. Between field turns of the alternating current motor, on the other hand, there is an active electromotive force similar to that between the turns of a transformer winding. A short circuit between field turns in an alternating current motor, therefore, means a destructive short circuit and an immediate interruption of service from that motor. As an offset against this disadvantage the alternating current motor possesses the advantage of being capable of operation at low voltage, thereby reducing the number of turns on the series field and increasing the proportionate space for insulation. The use of a step-down transformer on the car makes available any desired voltage at the motor. This existence of an active electromotive force between field turns is the most serious obstacle to the use of high voltage on the motor.

This limitation of available space for the motor and the existence of an active electromotive force between field turns makes it seem probable to the writer that the alternating current railway motor of the future will be operated at low voltage, and will receive its current from a transformer carried on the car.

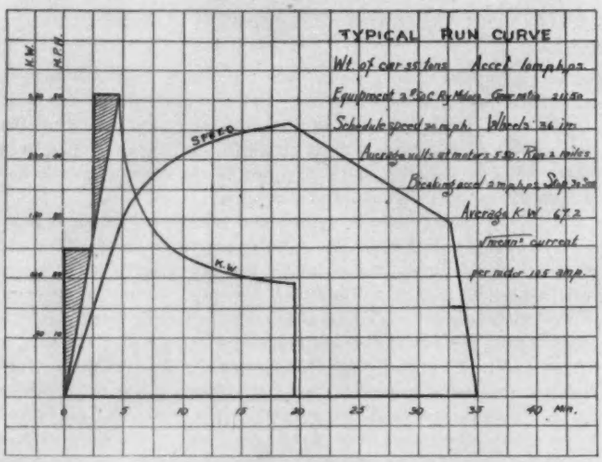


FIGURE 1. TYPICAL RUN CURVE WITH DIRECT CURRENT MOTORS

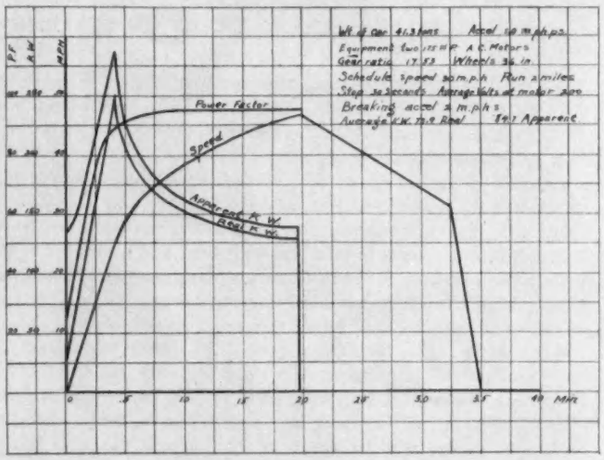


FIGURE 2. TYPICAL RUN CURVE WITH ALTERNATING CURRENT MOTORS

5. It is a question whether alternating current in the rails will interfere with telephones and similar instruments more than the direct current, which they have to contend with at present. In any event, the amount of current in the rails can be reduced by the use of higher voltages, so that this source of interference can be made less than it is with the present direct current system.

A COMPARISON OF A. C. AND D. C. SYSTEMS

The engineer has been defined as a man who could do for $1.00 what any fool could do for $2.00. The engineer, in other words, stands for efficiency. It is he who accomplishes a given result with a minimum expenditure of effort and money. Suppose we apply this criterion to the comparison between the alternating current and direct current systems. By which of these systems can a given service be rendered most economically? In order to answer this question we shall assume a certain typical interurban road, ascertain the first cost by both systems and the cost of operating by both systems and compare the results. Suppose the typical road, which we will assume to be as follows: Length, sixty miles; schedule speed, thirty miles per hour; cars running half-hour apart, number of stops thirty, that is, typical run, two miles long; eight of direct current car, complete, thirty-five tons, weight of alternating current car, complete 41.3 tons.

Figure 1 shows the speed-time and kilowatt-hours curve of a

direct current car of thirty-five tons over the typical run. The equipment, gear ratio, acceleration, etc., are given on the curve.

Figure 2 shows the same for an alternating current typical run, and in addition gives also the apparent kilowatts and power factor. It will be noted that the difference in power at the car is only 10 per cent. in favor of the direct current equipment, in spite of the fact that the difference in weight is 18 per cent. in favor of the direct current.

The location of the power house is assumed in both cases to be on the line of the road midway between the termini, therefore, thirty miles from each terminus. In each case, also, one of the substations is located in the power house. In the alternating current proposition the generators are wound for trolley voltage (3000 volts) and feed directly into the trolley. In each case, also there are supposed to be four feeding points beside the power house, thus making the substations twelve miles apart in both cases. Further, in both cases the secondary system is a single network, thus gaining the advantage of two feeding points, except beyond the end substations. In neither system are secondary feeders figured on, the alternating current being simply a No. 0000 trolley wire throughout, and the direct current a sixty-pound conductor rail. In the direct current system the high tension line is supposed to be along the right of way of the road, and the high tension poles are utilized for supporting the trolley wire with a bracket construction. Recognition of the fact that the alternating current car is the heavier and requires more energy is made, and larger motors than on the direct current car estimated on. In the direct current proposition the generators, transmission line, etc., are supposed to be three-phase, naturally making necessary smaller transformers than in the single-phase system.

The following parallel columns give complete comparison of the power consumption, the losses in the various transmissions and transformations, the first cost of the apparatus used and an estimate of the operating expenses. The conditions are taken as nearly as possible to those in the typical road. Location will, of course, make differences in many of the items considered, but especial care has been used in estimating those items in which the two systems present a difference:

DIRECT CURRENT RAILWAY SYSTEM.		ALTERNATING CURRENT RAILWAY SYSTEM.	
Power Requirements—		Power Requirements—	
Average kilowatt at car in typical two-mile run (Figure 1).....	67.2	Average real kilowatt at car in typical two-mile run (Figure 2)..	73.9
Number of cars running at one time.....	8	Number cars running at one time.....	8
Number of substations.	5	Number of substations.	5
Average number cars per substation.....	1.6	Average number cars per substation.....	1.6
		$\sqrt{\text{Mean}^2}$ apparent kilowatt per car.....	129.0
$\sqrt{\text{Mean}^2}$ amperes per car.....	185.3	$\sqrt{\text{Mean}^2}$ amperes per car (3000 volts).....	43.0
$\sqrt{\text{Mean}^2}$ amperes per substation = m.....	279.0	$\sqrt{\text{Mean}^2}$ amperes per substation = m.....	68.8
With substation twelve miles apart, eighty-pound track rail and sixty-pound third rail resistance between adjacent substations is = r.....0.9 ohms		With substation twelve miles apart, eighty-pound track rail and No. 0000 trolley, resistance between substations allowing for increased rail resistance.....4.2ohms	
Direct current line loss per substation $\frac{r\ m^2}{6} = 16.1$kw		Trolley and rail loss per substation $\frac{r\ m^2}{6} = 3.32$kw	
Average kilowatt per substation at cars = 67.2×1.6=.....	107.5	Average real kilowatt per substation at cars =73.9×1.6=.....	118.0
Average kilowatt per substation at substation.....	123.6	Average real kilowatt per substation at substation.....	121.32
		Per cent. loss in regulator and car transformer.....	5.0
Per cent. loss in third rail.....	15.5	Per cent. loss in trolley and rails.....	2.8
Per cent. loss in step-down transformers...	3.5	Per cent. loss in step-down transformers..	3.5
Per cent. loss in rotaries	10.0		
Per cent. loss in high-tension line.....	2.5	Per cent. loss in high-tension line.....	2.5
Per cent. loss in step-up transformers....	3.5	Per cent. loss in step-up transformers.....	3.5
Total per cent. loss from cars to power house.....	39.5	Total per cent. loss....	18.4
Average kilowatt consumed by eight cars at the cars.....	537	Average real kilowatt consumed by eight cars at the cars.....	591
Average kilowatt at power house for eight cars.....	750	Average real kilowatt at power house for eight cars.....	700
		Average apparent kilowatt at power house, about.....	825
Maximum load per substation—worst condition, two cars starting	560	Maximum load per substation—worst condition, two cars starting (say 275 apparent kilowatt each).....	550
One 400-kilowatt rotary will take care of this 40 per cent. overload.		One 350-kilowatt transformer will take care of this with 50 per cent. overload.	
Average load on rotary	30%	Average load on substation, about.....	40 %
Rotary substations are of sufficient size so that one can be cut out temporarily.		These transformers are sufficiently large to take care of road if one is cut out.	
Maximum load on power house, say 1200 kw		Maximum load on power house in apparent kilowatt, say 1400 k w	
Can be taken care of with three 400 kilowatt generators—one for spare.		Can be taken care of with three 450 kilowatt generators—one for spare.	
Step-up Transformers—		Step-up Transformers—	
Seven 150-kilowatt transformers—1 for spare.		Three 400-kilowatt transformers—load can be carried by two in case of emergency.	
High-tension Line—		High-tension Line—	
One No. 6 B. & S. guage line each way from power house, 20,000-volt, three-phase.		One No. 3 B. & S. guage line each way from power house, 20,000-volt, one-phase.	
Maximum loss, about..	8.25%	Maximum loss about...	8.2%
Average loss, about....	2.50%	Average loss, about....	2.7%
Substation Equipment—		Substation Equipment—	
Five substations in all—one in power house.		Four substations—power house feeds directly into 3000-volt trolley.	
Each of four substations to contain:		Each substation to contain:	
Three 135-kilowatt step-down transformers.		One 350 kilowatt transformer.	
One 400-kilowatt rotary converter.			

Switchboard.	
Step-down transformers omitted in power house substation.	
Low Tension Distributing System—	
Entire length of track equipped with 60-pound conductor rail.	
Car Equipments—	
Each car equipped with two 150-horsepower direct connected railway motors and multiple control apparatus complete.	
ESTIMATED FIRST COSTS OF ELECTRICAL EQUIPMENT.	
Power Station—	
Three 400-kilowatt, 25-cycle, 360-volt, three-phase, alternating-current generators, at $6,500 each	$19,500
Seven 150-kilowatt, 350-volt to 20,000-volt, self-cooling, oil-insulated transformers, 25 cycle, at $1,225	8,575
Switchboard	4,500
	$32,575
High Tension Line—	
48 miles of 20,000-volt, three-phase transmission line—No. 6 B. & S. gauge conductors, at $900 per mile	$43,200
Lightning protection	2,500
	$45,700
Substations—	
Twelve 135-kilowatt, 20,000 and 360-volt, 25-cycle, O. I. S. C. transformers, at $1,175 each	$14,100
Five 400-kilowatt, 600-volt, 25-cycle rotary converters, at $5,200 each	26,000
Five switchboards, at $2,800 each	14,000
	$54,100
Low Tension Distributing System—	
63 miles of 60-pound conducting rail, at $2,500 per mile, installed	$157,500
Bonding main track—	
63 miles, at $400 per mile	25,200
	$182,700

Switchboard.	
Low Tension Distributing System—	
Entire length equipped with No. 0000 B. & S. guage trolley.	
Car Equipments--	
Each car equipped with two 165-horsepower alternating-current railway motors, with multiple control apparatus complete.	
ESTIMATED FIRST COSTS OF ELECTRICAL EQUIPMENT.	
Power Station—	
Three 450-kilowatt, 25-cycle, 3,000-volt one-phase, 2,000 alternating generators, $7000 each	$21,000
Three 400-kilowatt, 17-cycle, 3,000 to 20,000-volt, O.I.S.C., transformer, at $2,500	7,500
Switchboard	3,800
	$32,300
High Tension Line—	
48 miles of 20,000-volt, one-phase transmission line—No. 3 B. & S. gauge conductors, at $1200 per mile	$57,600
Lightning protection	2,000
	$59,600
Substations—	
Four 350-kilowatt, 2000 alternations 2000-volt to 3000-volt, O. I. S. C. transformers, at $2200 each	$8,800
Five switchboards, at $1,500 each	7,500
Auxiliary signaling lines for operating substation switches	7,500
	$23,800
Low Tension Distributing System—	
63 miles of No. 0000 trolley wire in place, at $900 per mile	$56,700
Bonding main track 63 miles, at $400 per mile	25,200
15 miles of pole construction not included in horsepower lines at $630 per mile	9,450
	$71,350

Car Equipment—	
Twelve direct current car equipments complete, consisting of two No. 50-C motors, with multiple-control outfit, heaters and contact shoes, at $5,217 each	$62,604
Total first cost electrical equipment	$377,179
ESTIMATE OF YEARLY OPERATING EXPENSES.	
Direct Current System—	
Five men, at power house, two shifts, average wage $900 per year	$9,000
One man at each of four substations, two shifts, at $900 per year each	$7,200
Fuel, water, oil, etc., at one-half cent per kilowatt hour—4,890,000 kilowatt hour	24,450
Repairs and maintenance of powerhouse (3 per cent. of cost per year)	971
Repairs and maintenance of high tension line (5 per cent. of cost per year)	2,285
Repairs and maintenance of substations (4 per cent. of cost per year)	2,064
Repairs and maintenance of third rail (1 per cent. of cost per year)	1,822
Repairs and maintenance of car equipments (12 per cent. of cost per year)	7,512
Total yearly operating expenses	55,404

Car Equipment—	
Twelve alternating current car equipments complete consisting of two 165-horsepower motors, with multiple-control outfit, heaters and trolley, at $8482 each	$101,774
Total first cost electrical equipment	$308,824
ESTIMATE OF YEARLY OPERATING EXPENSES.	
Alternating Current System—	
Five men at power house, two shifts, average wage $900 per year each	$9,000
Fuel, water, oil, etc., at one-half cent per kilowatt hour	23,050
Repairs and maintenance of powerhouse (3 per cent. of cost)	969
Repairs and maintenance of high tension lines (5 per cent. per year)	2,980
Repairs, maintenance and inspection of substations (6 per cent.)	1,428
Repairs and maintenance of trolley (4 per cent. per year)	3,652
Repairs and maintenance of car equipments (10 per cent.)	10,177
Total yearly operating expenses	51,256

LARGE FIRE PUMPING STATION FOR PHILADELPHIA.

THE desirability of providing separate mains for domestic water supply and for fire service has long been evident to those interested in fire insurance matters. The existence of two systems of mains not only greatly diminishes the possibility of a failure of the water supply, but very often makes it possible to carry a water pressure sufficient for fire protection without the need of fire engines. This is of special importance in crowded districts where fire engines are frequently subject to delay and often prove inadequate in fighting fire in modern high office buildings. While it would be possible to carry a high-pressure in the regular service mains, it is entirely impracticable, not only because of the extra pressure, but also the increased leakage and cost of fittings, loss of pressure, etc. Where a high pressure is maintained in separate fire mains, the individual fire protection systems of buildings may be so connected that water is always available on any floor of the tallest building.

However, it is not always advisable to maintain such a service from a municipal water-works plant, often because the distance through which it would be necessary to carry the high-pressure mains would be unnecessarily great, and, moreover, an accident

to the plant might disable both services. The high-pressure pumping engine would probably be of a type different from the regular service engines and little economy would be gained by placing them in the same station, further than a possible saving in attendance.

Many considerations favor locating the fire pumping station directly in the heart of the district to be protected. The character of the motive power then becomes the next consideration. If steam is used it will be necessary to keep steam up in the boilers continuously, although the plant may be called into action only once or twice during a year. Electricity has also been proposed, and it might be advisable where connection could be had with a number of independent electric supply circuits, thus minimizing the chances of shut-down.

In one of the latest plants of this character to be installed, gas engines have been chosen, the fuel supply being taken from the city illuminating gas mains.

The installation to which we refer has recently been completed in the city of Philadelphia, and is located on the Delaware River front, at the corner of Race Street and Delaware Avenue. The district protected is bounded by Broad, Walnut and Race Streets and the Delaware River and contains many high office buildings. The pumping station, which occupies a building seventy-two by 140 feet, will contain ten eleven-and-one-half by-twelve-inch, vertical, direct-acting, Deane triplex pumps, each capable of delivering 1200 gallons per minute at forty revolutions, against a pressure of 300 pounds per square inch. There are also two six-and-one-quarter-by-twelve-inch pumps of the same type of 350 gallons capacity per minute. These pumps are to work together or singly, as may be desired, and all will discharge into a common twenty-inch main. The water supply for the pumps will be taken directly from the Delaware River through a thirty-six-inch suction main. Only seven of the larger pumps are being installed at present. Each of the large pumps will be driven by a 280-horsepower, Westinghouse, three-cylinder, single-acting gas engine, and the small pumps by engines of the same type of 125 horsepower each. The smaller engines will be direct-connected to the smaller pumps through friction clutches, and will also drive electric ignition generators of seventy-five kilowatts each and the air compressors supplying air at 200 pounds pressure for starting the main engines. There are three sources of current for ignition, connections with the city lighting mains and a storage battery being provided in addition to the ignition generators. The lighting current is reduced from 220 to 110 volts by a rotary transformer. Cooling water for the gas-engine cylinders may be taken from two different city water mains and from the fire mains. A gas pressure regulator on the supply pipe of each engine maintains the pressure constant.

Triplex pumps have been selected because of the even flow of the discharge, producing practically constant pressure on the discharge mains and making a very even load through all parts of the gas engine cycle. The crank shafts are driven from the engine shafts through single-reduction gears. The fact that the pumps are of the vertical type makes it very easy to connect the pumps directly to the engines, and also results in a considerable saving in space.

Each pump is fitted with a by-pass valve and a relief valve, the manner of using these valves being well described in the following clause from the specifications:

"It is proposed to maintain about sixty pounds pressure on the fire mains from the city reservoir. The pumps will be started under these conditions with the by-pass open, and any surplus of water pumped will be discharged through the relief valve into the suction main. When the engine is under way the by-pass will be closed, and when the water is used as fast as this unit will deliver it, its relief valve will close. In the mean time a second unit will be started and handled in the same way, and so on until the full plant is in operation."

The pressure on the fire mains is controlled automatically by an electric motor acting on a valve. It may be held steadily at any point under 300 pounds, while a spring relief valve prevents it from rising above that amount.

The water ends of the pump are divided into sections; that is, each cylinder and valve chest is a separate casting and can easily be removed by itself without disturbing the other parts of the machine. This makes a very convenient arrangement in case repairs are ever required for the water-end parts. The pumps have very large valve areas and are capable of a very much higher speed and much greater pressure than are called for in the specification. The valves are of hard rubber, especially suited for this work.

The machines were especially designed for fire service by the Deane Steam Pump Company, of Holyoke, Mass., and are brass fitted throughout in order that they may be able to start after long periods of idleness. All of the moving parts, such as bearings, connecting rods, crank-pin boxes, cross-head shoes, etc., are adjustable for wear. The crank shafts and connecting rods are made of forged compressed steel, have large factors of safety and are much superior to the steel castings sometimes used for this purpose. The pinions are of steel and the gears are of steel castings, all carefully cut by machine and running with little noise. The pumps are very heavy in every particular and insure that all requirements on the pumping end of the equipment will be met.

The mains supplied by this pumping station are nine miles long and consist of pipes eight, twelve and fifteen inches in diameter. They are of extra thickness, and all fittings, including fire plugs, are of special design. The total weight of the pipe is 6,500,000 pounds, and of the fittings, 850,000 pounds, costing altogether $355,000. The pump house cost $250,000, the large units $22,000 each and the small units $8000. The station replaces with advantage more than forty fire engines, and as a result of its installation the rate of insurance will be reduced 25 cents per $100.

The selection of gas engines for motive power is novel, but is believed to be justified in view of the perfection of the modern gas engine as regards reliability and freedom from break-down. The great advantages incident to the use of gas engines are their economy during periods of idleness, as compared with steam plants, and the ability to start up immediately and at full power.

THE NURNBERG GAS ENGINE.

AN announcement of much importance to the gas industry throughout the United States is contained in the advertisement of the Allis-Chalmers Company in this issue of THE JOURNAL.

It will be noted that the company has acquired the exclusive rights for the manufacture and sale of the Nurnberg gas engine in the United States, Canada and Mexico.

The Nurnberg is considered the highest type of gas engine on the market today, and has met the most exacting demands as to power efficiency and economy that could be required. With this addition to the already long list of the output of the Allis-Chalmers Company, it is not strange that they invite correspondence relative to the installation of complete gas power plants.

PERSONAL.

H. F. J. Porter, who has been associated with Westinghouse interests since the first of the year, and has held the position of assistant manager of the publishing department, with offices in East Pittsburg and 10 Bridge Street, New York, has been made second vice-president of the Nernst Lamp Company, of which enterprise George Westinghouse is president. Mr. Porter assumed charge on December 1st, with the duties of general manager and headquarters at Pittsburg. This appointment does not affect Mr. Porter's relations with the publishing department at the present time.

REMOVAL NOTICE.

We beg to announce that after February 1, 1904, the main office of Jno. Martin & Co. will be located on the second floor of the Crossley Building, 83-85 New Montgomery Street, San Francisco.

The Journal of ELECTRICITY POWER and GAS
DEVOTED TO THE CONVERSION, TRANSMISSION and DISTRIBUTION OF ENERGY.

PUBLISHED MONTHLY BY
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Telephone Main 1264.

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ADDRESS ALL COMMUNICATIONS AND MAKE ALL REMITTANCES PAYABLE TO THE JOURNAL OF ELECTRICITY PUBLISHING COMPANY.

This paper is a member of the National Trade Press Association.

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VOLUME XIV FEBRUARY, 1904 NUMBER 2

EDITORIAL.

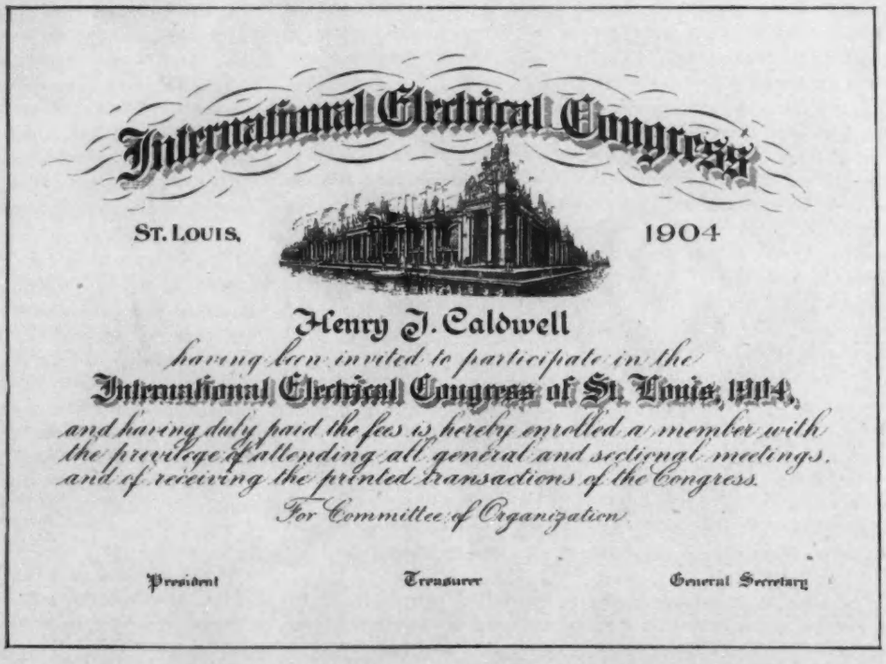
INTERNATIONAL ELECTRICAL CONGRESS

According to the present indications, the International Electrical Congress, to be in session at St. Louis September 12–17, 1904, will be one of the most successful that has yet been held, both with respect to the number of adhesions and to the value of the transactions.

Up to date about 3550 circular letters of invitations to join the Congress have been issued to persons or associations in North America. From these 875 post-card accceptances of membership have been received. About 350 similar circular letters of invitation have recently been sent to other countries. It is intended to issue in all about 5000 invitation circulars in America and about 6000 in foreign countries. It is expected that many persons will join the Congress, both in America and abroad, who do not expect to attend the sessions in St. Louis, in order to secure a copy of the transactions, which will form one, and perhaps two, large octavo volumes. Collection of fees has commenced, and upon receipt thereof the member will be forwarded a certificate of membership, a reproduction of which is shown herewith. The certificate is 8½ inches by 11 inches in size (21.5 centimeters by 28 centimeters) and printed on heavy paper of excellent quality.

Recently 280 special letters of invitation were issued on behalf of the Committee of Organization to prominent electricians and electrical engineers, signed by the president and general secretary of the committee, requesting papers for the Congress in the various sections. Of these 146 have been sent to foreign authors and 134 to American authors. There has not been time to receive replies from more than a few foreign authors, but twenty-one acceptances have up to date been received from abroad and forty-six from North America. Sixty-seven papers are thus already promised for the Congress and the number is steadily increasing. A considerable number of invitations to contribute papers have yet to be issued. It is hoped that the Congress will convene with a full program in each section, and that at least half of the papers may be from foreign countries. According to the plans of the committee, papers for the Congress program are specially invited, but papers voluntarily offered will be submitted to the officers of the sections to which the papers belong, and may be included in the program by invitation at their request, if the subjects are desirable, and if the schedule allotted to each section will permit, it being the desire of the section officers to secure and offer the best possible program and presentation.

Petitions from the Congress Committee of Organization and from the president of the American Institute of Electrical Engineers have been filed with the Department of State at Washington, through the Department of Commerce and Labor and the National Bureau of Standards, urging that the various foreign governments should be invited to appoint official delegates to the Congress. The lists of such delegates to be invited is in accordance with the lists allotted to the various countries at the Paris Congress of 1900 and the Chicago Congress of 1893. Including the United States the lists comprise fifty-six official delegates. Information has been received that these petitions have been granted, and that the State


International Electrical Congress
ST. LOUIS, 1904
Henry J. Caldwell
having been invited to participate in the
International Electrical Congress of St. Louis, 1904,
and having duly paid the fees is hereby enrolled a member with
the privilege of attending all general and sectional meetings,
and of receiving the printed transactions of the Congress.
For Committee of Organization
President
Treasurer
General Secretary

Department on the 17th of December, 1903, instructed the diplomatic officers of the United States abroad to extend an invitation to foreign countries to be represented at the Congress by delegates.

Arrangements are being made with a view to perfecting plans of co-operation between the Congress and electrical societies and associations in various parts of the world. Invitations have already been extended to the Congress members to visit places of electrical interest on the journey to or from St. Louis.

The Committee of Organization of the Congress consists of Elihu Thomson, president; A. E. Kennelly, general secretary; W. D. Weaver, treasurer; Bion J. Arnold, vice-president and chairman of the executive committee; C. F. Scott, Dr. S. W. Stratton, Professor H. S. Carhart and Professor W. E. Goldsbrough, vice-presidents.

The following section officers have been appointed by the president, and have already done much work in organizing their sections:

Section A, General Theory—Professor E. L. Nichols, Cornell University; Professor H. T. Barnes, McGill University.

Section B, General Applications—C. P. Steinmetz, Schenectady; Professor Samuel Sheldon, Brooklyn.

Section C, Electro-chemistry—Professor H. S. Carhart, University of Michigan; Carl Hering, Philadelphia.

Section D, Electric Power Transmission—C. F. Scott, Pittsburg; Dr. Louis Bell, Boston.

Section E, Electric Light and Distribution—J. W. Lieb Jr.; G. S. Dunn, New York.

Section F, Electric Transportation—Dr. Louis Duncan, Massachusetts Institute of Technology; A. H. Armstrong, Schnectady.

Section G, Electric Communication—F. W. Jones, New York; Mr. Bancroft Gherardi, New York.

Section H, Electro-therapeutics—Dr. W. J. Morton, New York; W. J. Jenks, New York.

All communications should be addressed to the general secretary, A. E. Kennelly, Harvard University, Cambridge, Mass.

TRANSFORMER REGULATIONS FOR BUILDINGS.

The following notice has been sent out by the Board of Fire Underwriters of the Pacific:

SAN FRANCISCO, January 25, 1904.

Memorandum of the Conference of the Representatives of the Board of Fire Underwriters, Electric Light Companies and the Department of Electricity, Concerning the Interpretation of Rule 36 of the National Electric Code, Relative to the Installation of Transformers in Buildings.

All transformer installations in buildings in the City and County of San Francisco shall be in accordance with Rule 36 of the National Electric Code, 1903, further definitely defined as given below:

Rule 36. Transformers (when permitted inside buildings)—Transformers must not be placed inside of buildings without special permission from the inspection department having jurisdiction.

(*a*) Must be located as near as possible to the point at which the primary wires enter the building.

(*b*) Must be placed in an inclosure constructed of fire-resisting material; the inclosure to be used only for this purpose, and to be kept securely locked, and access to the same allowed only to responsible persons.

(*c*) Must be effectually insulated from the ground, and the inclosure in which they are placed must be practically air-tight, except that it must be thoroughly ventilated to the outdoor air, if possible, through a chimney or flue. There should be at least six inches air space on all sides of the transformer.

In order to obtain the approval required of the Inspection Department, as stated above, transformers must be safeguarded by resting on concrete of at least three inches in depth; be placed immediately under the sidewalk in an inclosure, which must be ventilated by an opening at least six inches square through the sidewalk, or to a chimney or flue. The fire-resisting material used in constructing the inclosure in which the transformer is located, and by which it is effectually cut off from the remaining part of the basement, must consist of a brick or concrete wall at least eight inches in thickness, access to which must be by an approved fire door. The transformer door so constructed must be supplied with sills, to prevent the flow of oil into the basement in case of explosion.

As an alternative to the above construction, the transformer may be placed in a tight steel tank ventilated to the street and standing on concrete.

R. M. LLOYD,
Manager District "A."

PUBLICATIONS.

"MODERN WIRING DIAGRAMS AND DESCRIPTIONS FOR ELECTRICAL WORKERS," by Henry C. Horstman and Victor H. Tousley. Size, 4¾x6½ inches; 157 pages and 176 illustrations. Published in flexible leather by Frederick J. Drake & Co., Chicago, 1904.

This work is described on its title page as being "a handbook of practical diagrams and information for electrical construction work, showing at a glance all that ordinary electrical workers need, nothing that they do not need." The authors have thus shown their purpose, and with charming frankness they say in the preface that "this little book is an attempt to supply working electricians and students of practical electrical matters with just such information as will assist them to take up any line of electrical construction work." They have done well in their attempt, but had they committed themselves to supply information for the guidance chiefly of bell-hangers and inside wiremen, they would have done well, and in the new editions which are certain to come they will probably score a signal success in the compilation of a work that shall be a universal compendium of wiring diagrams.

The idea of collating diagrams of this character is one that appeals to every wire-man and engineer, and the singular feature of the literature of practical electrics is that no one has done it heretofore in any but a cursory way. In fact, the present book is the nearest approach to perfection that has yet been attained in its direction. Its shortcomings are but few—to the reviewer's mind, at least, they are serious. The wire-man, for instance, will find naught to instruct him in the matter of phase conversions, for, although the book gives diagrams of transformer connections for single-phase, two-phase, three-wire and three-phase work, the latter being in both delta and star connection, not a line is given upon that most important direction of transformer development which enables them to be connected in any one of a dozen ways for converting say a two-phase service into a three-phase service, or *vice versa*. If the authors are wise, they will gain consent to avail themselves of the invaluable information upon this point that is contained in the confidential engineering bulletins of the principal electrical manufacturing companies. Then, too, the subject of switchboard connections is an inexhaustable one, yet only the switchboards of two circuits are presented, and they are direct-current series arc switchboards at that. Special features of switchboard work are entirely omitted. Why not something on synchronizing circuit connections, on

end cell indicators, on potential regulation in polyphase panels, and, in brief, on general power switchboard construction? The single diagram given of the connections of a storage battery and motor-generator booster set could well be supplemented by another showing the remarkably interesting counter electro-motor-force booster arrangement used in conjunction with the Gould storage battery, while the chapter on testing, though a valuable one, would be rendered far more so were there added to it the invaluable series of diagrams by Dr. Meschke, showing the almost innumerable uses to which Weston voltmeters and ammeters can be put in testing work. These diagrams appeared in a serial published in the *Electrical World* in the spring of 1892.

But the reader should not permit these criticisms to be interpreted as disparaging to the book, for truly it is an excellent little volume. Judging from the contents of the work, it would appear that the authors are specialists in house wiring, for the opening sections of the book, which treat of call and alarm circuits, annunciators, bells, return call systems, fire and burglar alarms, telephones for interior purposes, the telegraph, gas lighting, automatic fire alarms, primary batteries, connecting-up and trouble are especially complete and exhaustive. Moreover the book is concisely yet lucidly written. In fact, there is no inside wire-man but would be a better man for possessing it.

HIGH-POWER WESTINGHOUSE-PARSONS STEAM TURBINES.

THE inauguration of the present century is marked by no more conspicuous event in American industrial development than the commercial introduction of the steam turbine for general power service. The ascendancy of the reciprocating engine for nearly two centuries has served to divert attention from its more efficient competitor, the turbine, and render public opinion singularly indifferent to the manners of the latter. The steam turbine has, however, found its way into public confidence, and, as a result of less than two decades of development, now completely outclasses, both in point of efficiency and capacity, the reciprocating engine in its present perfected form.

The Westinghouse-Parsons steam turbine was commercially introduced during the closing months of the last century. The sizes then built were of 600-horsepower nominal capacity, direct connected to 400-kilowatt polyphase generators. Subsequent development has been so rapid that within a period of four years turbines of 5500 kilowatts, or 7500-horsepower nominal capacity, have been designed and are under construction. These machines will have a continuous overload capacity of 11,000 horsepower in one self-contained unit, and thus rank among the world's largest prime movers.

Recently marine work has been contemplated by the builders, and the near future may be productive of turbines of still greater power, although of slightly different arrangement, necessary to adapt the present type to marine usage.

The 5000-kilowatt turbo-generating unit illustrated herewith (Figure 1) is representative of the general type which will be constructed for large powers. This type embodies the experience acquired in the construction and operation of a large number of machines.

The principle of operation, as well as the general relation and arrangement of rotating and stationary elements characteristic of former types, has been employed. The largest machines therefore find their direct prototypes in the original design adopted, in a measure vindicating the wisdom of adherence to the design of maximum simplicity, viz., the horizontal single-cylinder turbine.

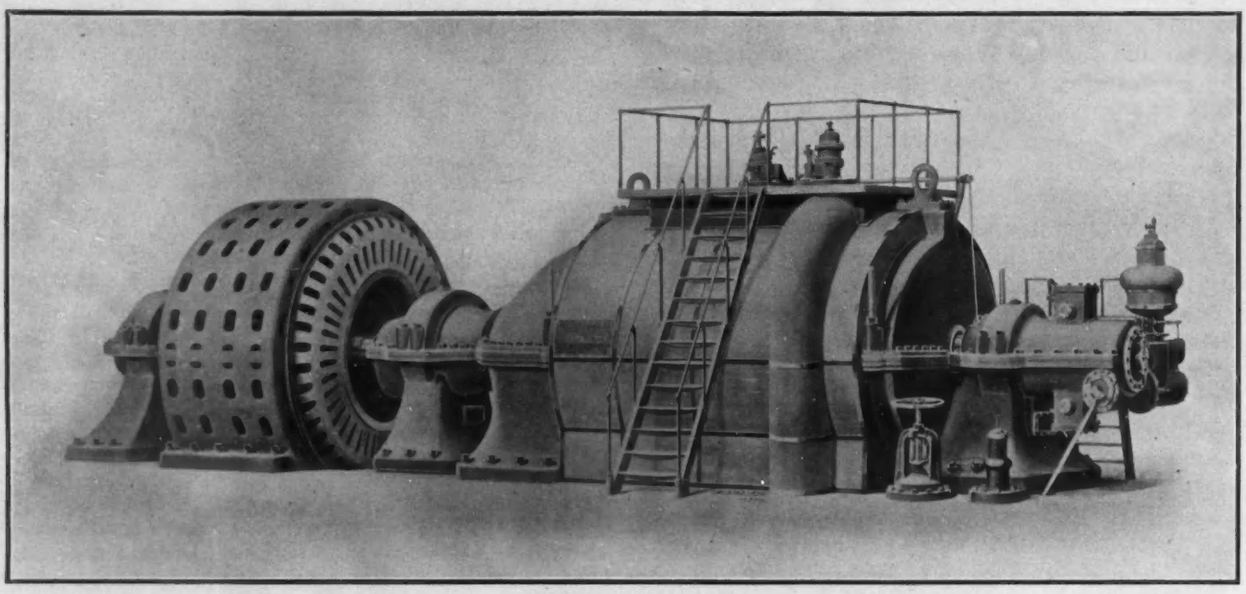


FIGURE 1. WESTINGHOUSE-PARSONS STEAM TURBINE

The most distinguishing features of the new type are the extreme compactness and low speed secured. These features have been practically prescribed by the necessity of minimizing the cost of power building construction for larger station capacities. The space occupied by the 7500-horsepower turbine is approximately 27 feet 8 inches by 13 feet 3 inches, and the height to the top of the hand railing is 12 feet. This is equivalent to .049 square foot (less than one-twentieth square foot) per electric horsepower capacity, or 20.2 horsepower per square foot of floor area required.

For the complete unit a rectangular area of 47 feet 4 inches in length and 13 feet in width is required, which is equivalent to .084 square foot per electric-horsepower capacity, or 12 electric-horsepower per square foot of floor space.

A graphical comparison of floor space required for different types of prime movers is shown in the accompanying curves (Figure 2). In all cases a complete unit is taken as the basis of comparison. This point of relative economy of space is well illustrated by Figures 3 and 4, which represent in plan and elevation the comparative space occupied by the 5000-kilowatt Manhattan Railway (New York) engine-type units and the 5000-kilowatt Westinghouse-Parsons turbine units.

In point of speed the new type fulfills the demand for a unit operating at moderate speed. The 5000-kilowatt units operate at 750 revolutions per minute, the 2000-kilowatt unit 1200-1560 revolutions per minute, and the 1000-kilowatt unit 1500-1800 revolutions per minute, depending upon the frequency desired.

These speeds, though not comparable to engine speeds, do not impose much greater stress upon the rotating parts, and in addition secure the great advantage of reduction in the bulk, weight and cost of the unit.

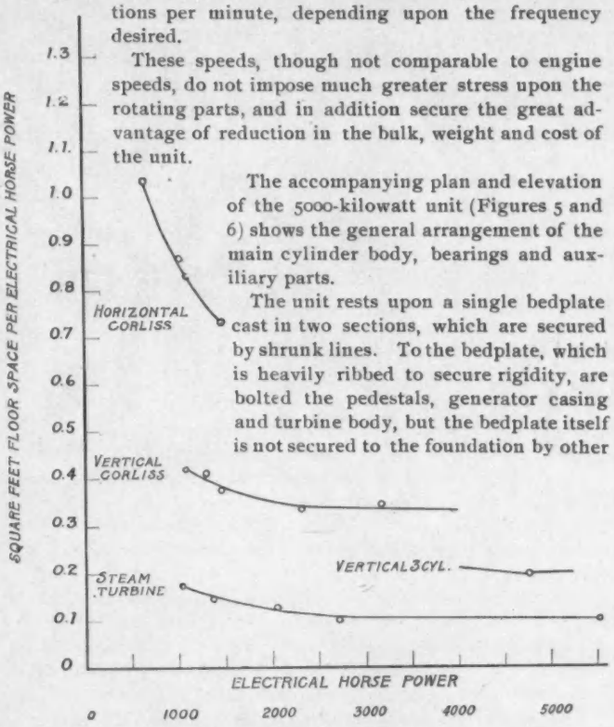


FIGURE 2. A GRAPHICAL COMPARISON OF FLOOR SPACE REQUIRED FOR DIFFERENT TYPES OF PRIME MOVERS

The accompanying plan and elevation of the 5000-kilowatt unit (Figures 5 and 6) shows the general arrangement of the main cylinder body, bearings and auxiliary parts.

The unit rests upon a single bedplate cast in two sections, which are secured by shrunk lines. To the bedplate, which is heavily ribbed to secure rigidity, are bolted the pedestals, generator casing and turbine body, but the bedplate itself is not secured to the foundation by other means than the weight of the unit. Steam and exhaust connections are made beneath the floor level.

In the smaller machines of this type the cylinder barrel of both journals are cast in a single casting, thus largely minimizing machine work. In the large machine, however, the barrel is cast in two sections united by links, the outboard section carrying the journal and worm casings, and the inboard section the journal and exhaust opening which extend through the bedplate. As in former types, linear expansion and contraction of the turbine are provided for by a sliding foot. The inboard journal pedestal is bolted securely to the bedplate, but the outboard pedestal is free to slide between parallel machined ways. The main body ef the casing is heavily lagged with non-conducting material, secured in place by sheet-steel casings.

Leakage of air from the atmosphere into the exhaust spaces of the casing at the entrances of the shaft is prevented by frictionless packing glands. No oil is employed, and in consequence the condensation from the turbine is pure distilled water.

In shaft construction great rigidity has been secured with minimum use of metal. A central steel quill carries the entire rotating parts, both blades and balance pistons. Hollow forged steel ends are forced into the two ends of this quill under hydraulic pressure, and are in addition secured by arrowhead links. High-pressure steam is conveyed to all parts of this quill structure in such a manner as to eliminate stresses and consequent distortion due to highly superheated steam.

Power is transmitted to the generator shaft through a flexible coupling, which is housed partly by the turbine and partly by the generator inboard journal. The coupling is split at the junction of the two shafts, so that by removing the bearing cap and the link bolts either section of the unit may be lifted out without disturbing the adjustment of the remaining section. In the smaller sizes the engagement surfaces of the coupling consist of the square or hexagonal ends of the shafts, but in the larger machines a crow-foot sleeve is keyed to each shaft and the power is transmitted to an outside quill engaging the crows-feet. Thus great flexibility is secured, together with the greatest facility in dismantling.

The journals of the larger machines are of the solid, self-aligning type, similar to that employed in generators and cross-compound engines. The departure from the familiar oil-cushioned journals employed in the small machines is occasioned by the speed reduction secured. The journal shells are babbitt-lined and are split horizontally, the two halves being united with bolts with shim adjustment. Oil from a central system is introduced at the center under slight pressure, thoroughly flushing all parts. Axial adjustment is provided by metal shims arranged in quarter-box fashion. The diameter of the shaft at the journal of a 5000-kilowatt machine is fifteen inches, strikingly small in comparison to the thirty-four-inch shafts required for a cross-compound reciprocating engine of corresponding capacity.

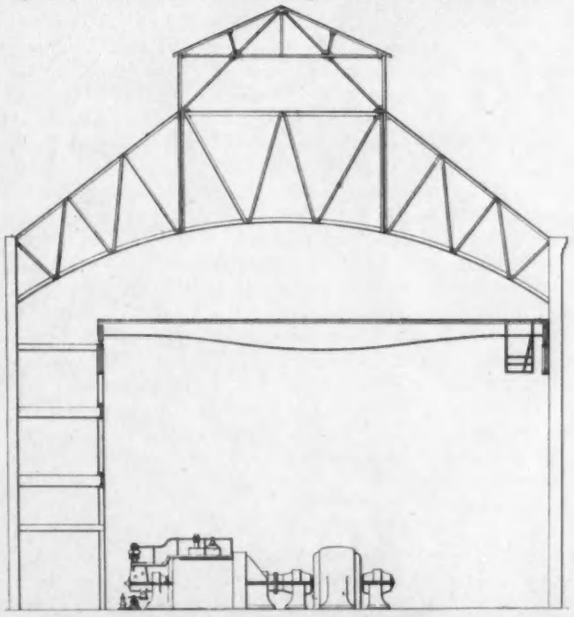


FIGURE 3. CROSS-SECUION OF MANHATTAN POWER HOMSE SHWING SPACE WHICH WOULD BE OCBUPIED BY 5000-KILOWRTT TURBO-GETERATOR

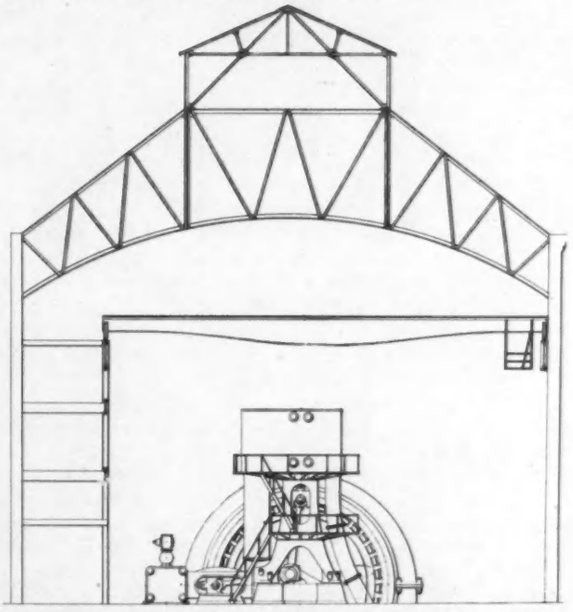


FIGURE 4. CROSS-SECTION OF MANHATTAN POWER HOUSE SHOWING SPACE WHICH WOULD BE OCCUPIED BY 5000-KILOWATT COMPOUND ENGINE AND GENERATOR

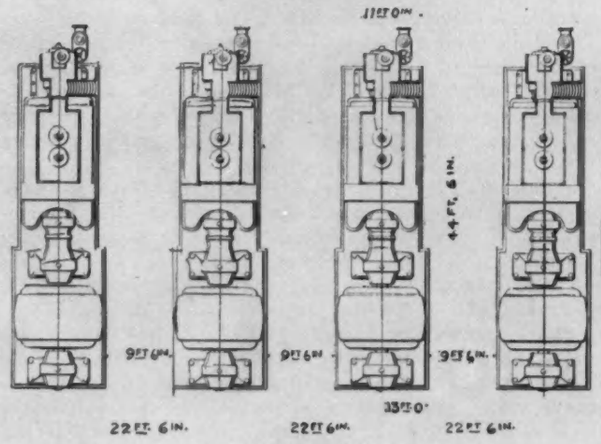


FIGURE 5. FOUR 5000-KILOWATT TURBO-GENERATORS

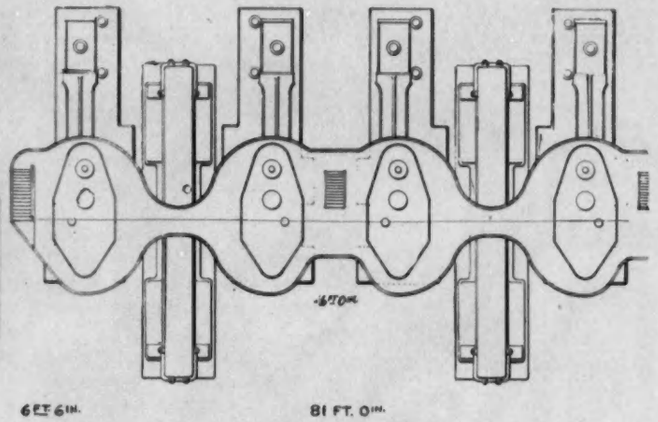


FIGURE F. TWO 5000-KILOWATT COMPOUND ENGINES AND GENERATORS

Longitudinal adjustment to preserve proper side clearance is secured by a thrust bearing located next to the outboard bearing. The bearing is not subjected to longitudinal thrusts from the action of the steam, and is consequently of small size.

The two half shells are advanced in opposite directions by graduated set screws, so that the actual running clearances are measured in thousandths of an inch. Once set, these adjustments are permanent and do not require frequent "taking up."

Steam enters the turbine successively through an automatic quick-closing throttle, hand throttle, strainer and the main admission valve. A circular steam port surrounding the entrance to the initial stage conveys this steam to all points, so as to avoid stresses incident to more localized admission of highly superheated steam.

An important feature of the steam distribution system is the provision of a by-pass valve. This valve admits high-pressure steam to the second stage of the turbine on overloads in order to increase its capacity, up to 50 per cent. in excess of full-rated load. By properly proportioning the by-pass steam to the overload on the turbine maximum economy may at all times be secured, together with reserve overload capacity. This results in a slight rise in the economy curve on heavy overloads, resembling in some respects the engine economy curve on loads exceeding those of maximum economy. The turbine, however only suffers in economy at heavy overloads, while the engine economy decreases progressively from 75 to 80 per cent. of full load capacity.

The main admission valve consists of a double-beat poppet valve operated by a small piston, this in turn being controlled by a small pilot valve directly actuated by the governor mechanism. The valve admits steam to the turbine in puffs, the duration of which are proportioned by the governor to the load upon the turbine. This intermittent method obviates the throttling of steam to accommodate loading and secures the highest economy by using at all loads steam at boiler pressure.

At the extreme outer end of the turbine shaft is mounted a worm driving a short horizontal cross shaft. This shaft drives at one end the oil shaft and at the other end the governor through bevel gearing. An eccentric provides the reciprocating motion necessary for the valve mechanism.

The governor is of the fly-ball type, with ninety-degree, bell-crank, ball levers mounted on knife edges and fitted with roller contacts. The governor sleeve and spring is mounted on ball bearings and the adjustment of the spring tension may be made while the turbine is running, thus affording a most simple and convenient means of paralleling alternating-current generators and dividing the load proportionately between them.

At the extreme end of the outboard pedestal is mounted an auxiliary speed-limit governor. It is likewise of the centrifugal type and may be set to release, at any predetermined speed, a small plunger valve which controls with high-pressure steam the operation of the quick-closing throttle before mentioned. This is normally held open by means of an overbalanced differential piston. At the moment the speed limit operates, the excess pressure is removed and the throttle closes. This device is employed purely for insuring absolute immunity from accident from excess speeds, due to the possible disablement of the governor mechanism.

Copious lubrication is supplied to all journals by means of a plunger pump driven from the worm shaft. The warm oil returning from the bearings passes through a copper coil cooler in the bedplate, and thence to a reservoir from which the pump draws its supply. The cooled lubricant is circulated at slight pressure, sufficient to insure positive flow. At no point is oil under high pressure employed for preventing erosion of rubbing parts, bearing areas being sufficient for supporting the area of the rotating parts.

In general construction the 5000-kilowatt turbo-generators conform to those now building for smaller machines. The field or revolving element is built from a solid cylinder of steel slotted for the reception of the bar windings and provided with ventilating openings corresponding with openings in the laminations of the stationary element. The generators may be wound for high voltage if desired, in order to avoid the use of step-up transformers in a system of power transmission at voltages ranging up to 15,000.

The 5000-kilowatt turbo-units here illustrated will be employed in heavy electric railway service, which is the most exacting encountered in central station operation. These machines will form the initial equipment of the Pennsylvania Railroad terminal property in New York City, operating with electric locomotives the heaviest Pullman trains through the tunnel approaches to Manhattan. Three units will similarly inaugurate the power service on the Philadelphia rapid-transit subway system now under construction. Eight 5000-kilowatt units will furnish power to the London subway system and three 3500-kilowatt units to the surface system of the same city. These units will operate under 175 pounds steam pressure, high vacuum, and 100 to 175 degrees of superheat.

Hunt, Mirk & Co., of San Francisco, are the Pacific Coast representatives of the Westinghouse Machine Company, and complete information can be obtained from them concerning the Westinghouse-Parsons turbine. They also handle a high grade water tube boiler, built and especially adapted for oil fuel, and a complete line of power machinery. The well known engineers, A. M. Hunt and Thomas Mirk, connected with this firm, will be sufficient assurance of the success of the Westinghouse-Parsons turbine on the Pacific Coast.

The Holland Company are carrying a full line of "Kearsarge" asbesto-metallic and vulcabeston products, including sheet, boiler gaskets, piston rod packings, and several other special varieties. They have packings which are especially adapted for oil and high pressure and superheated steam, as well as gas engine work.